Spotted Wing Drosophila Tsunami: SWD Management

2018 Agr.assistance Winter Fruitgrower Meeting
Tuesday March 6th
Ontario Country Club – 2101 Country Club Lane – Ontario, NY

Cornell University
Hudson Valley Research Laboratory

THE JENTSCH LAB

INSECT BIOLOGY, ECOLOGY, AND MANAGEMENT IN HUDSON VALLEY AGRICULTURAL COMMODITIES

Plant Protection Presentations

Recent presentations:

Spotted Wing Drosophila Tsunami: SWD Management. 2018 Agr.Assistance Winter Fruit Grower Meeting. Tuesday March 6th, Ontario Country Club – 2101 Country Club Lane – Ontario, NY

Monitoring and Management of the Stink Bug Complex In the Northeast presented to the Red Tomato – Annual Growers Meeting, February 28th , 2018, Henry A. Wallace Center, FDR Presidential Library Hyde Park, NY

Developing Attract-and-kill Strategies To Manage Spotted Wing Drosophila, Drosophila Suzukii Matsumara, In Raspberry. International Congress of Entomology, Orlando, FL. September, 2017.

Monitoring, Modeling And Managing The Lepidopteran Complex, Vermont Tree Fruit Growers' Association, Middlebury,

Search

2017 BLOG PAGES

- When Twenty-Six Thousand Stinkbugs Invade Your Home: New Yorker Magazine, Annals of Ecology March 12, 2018 Issue March 5, 2018
- Using Attract And Kill Stations To Monitor Brown Marmorated Stink Bug In Hudson Valley Orchards And Vegetable Crops. January 12, 2018
- Will Samurai Wasp Be The Answer.

http://blogs.cornell.edu/jentsch/presentations/

A Spotted Wing Drosophila Tsunami: SWD Management in NYS in 2017

- **Spotted Wing Drosophila (SWD) Biology & Ecology**
  - Hosts
  - Generational Cycles & Population Density
  - Temperature Constraints
  - Overwintering, Movement and Spread
- **Biological control**
  - Insect & Disease
- **Conventional Controls**
  - Timing, Materials
- **Alternative Control**

A Spotted Wing Drosophila Tsunami: SWD Management in NYS in 2017

- Spotted Wing Drosophila (SWD) is an invasive Southeast Asian species of vinegar fly, first reported in 1939 Japanese literature.
- Female SWD damages unripened & healthy fruit while depositing eggs into fruit.
- Wounded fruit have been found to contain microbial organisms, often leading to increased rot.

Female Drosophila species

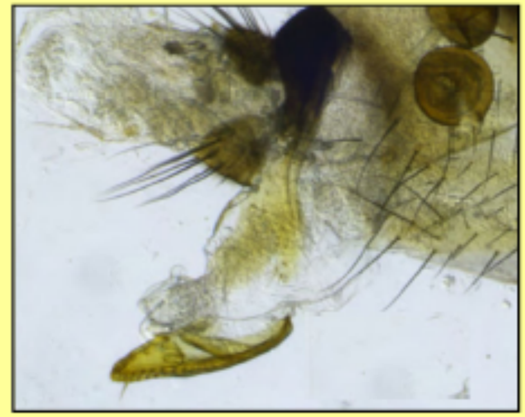
UC Berkeley & UC Cooperative Extension *Photos:* M. Hauser, CDFA

Spotted Wing Drosophila (D. suzukii)

SWD has a large, saw-like, serrated ovipositor with two even rows of teeth that are much darker than rest of ovipositor

Other Drosophila spp.

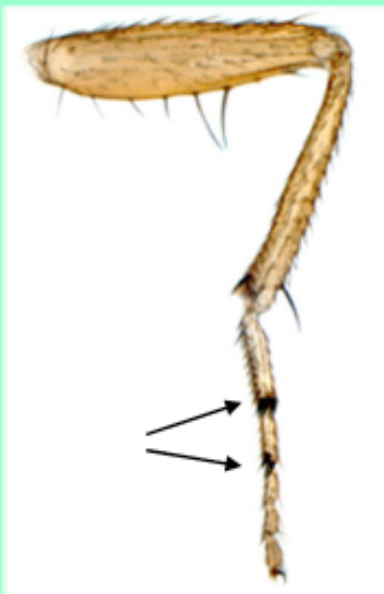
have smaller, more rounded ovipositors, sometimes with irregular, poorly defined teeth



Male Spotted Wing Drosophila (SWD)

UC Berkeley & UC Cooperative Extension

Photos: M. Hauser, CDFA



Double stripes on tarsi of front legs

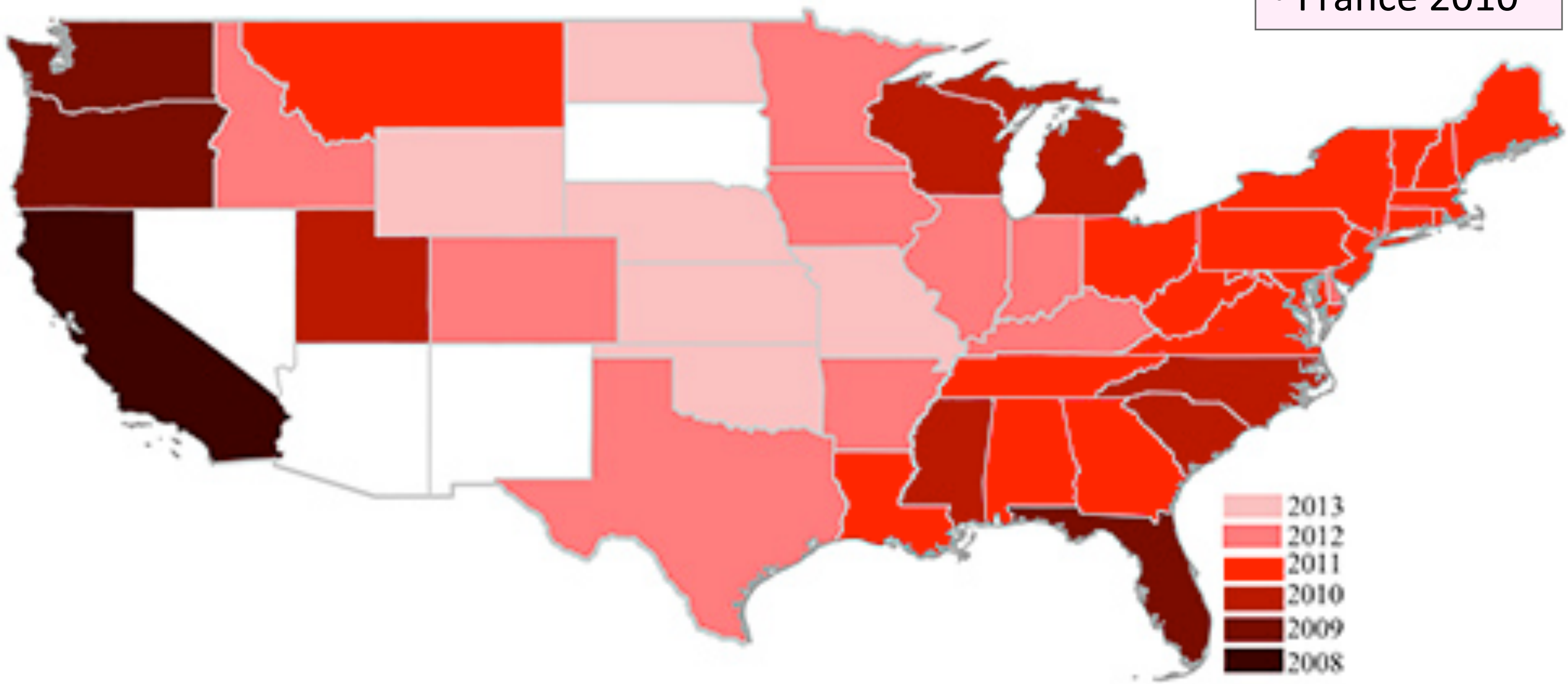
Leading edge of wing has dark spot

Unbroken abdominal bands

SWD Spread from 2008 – 2013 in the US

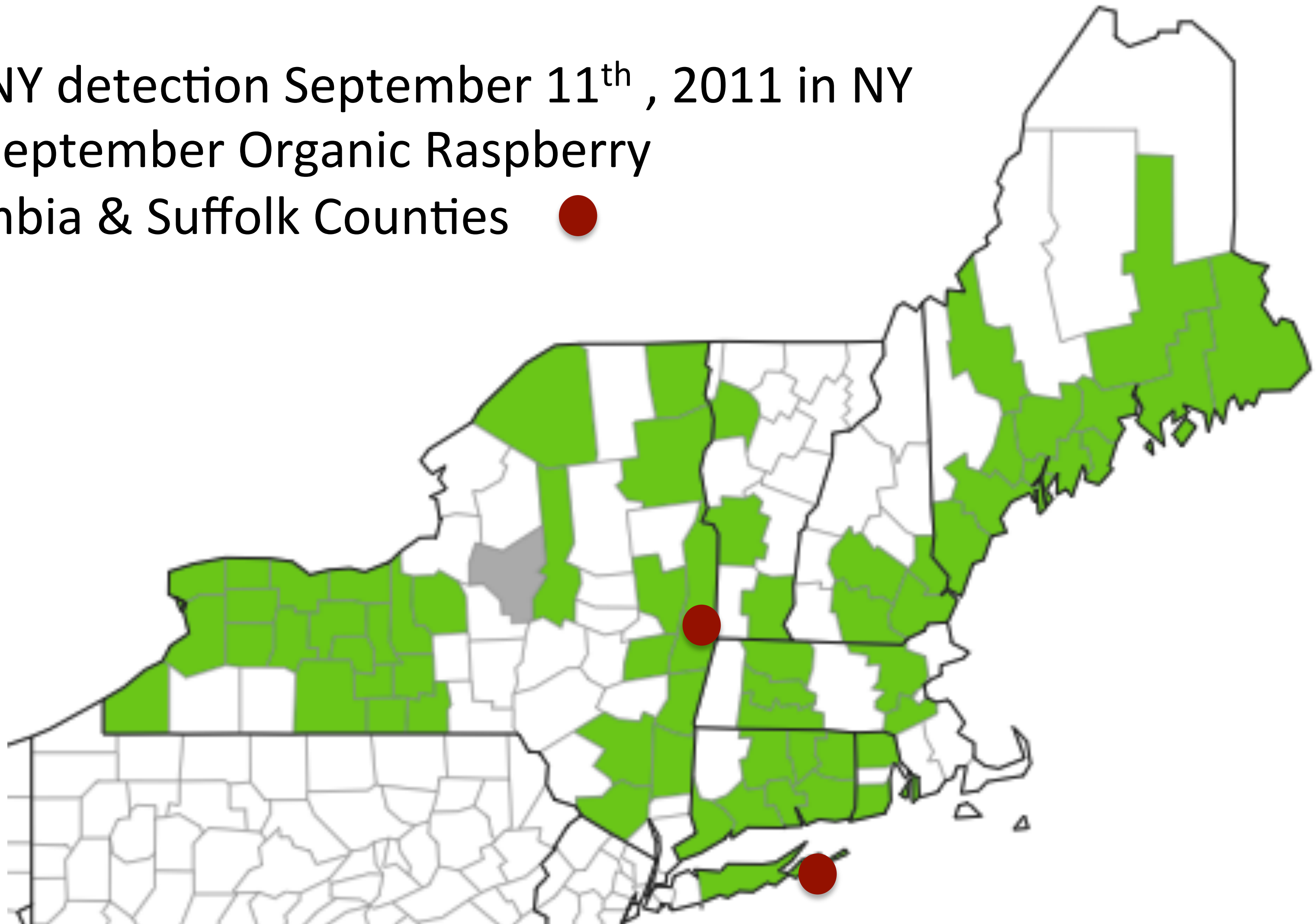
Hawaii 1980

- Italy 2009
- Russia 2009
- Spain 2009
- France 2010



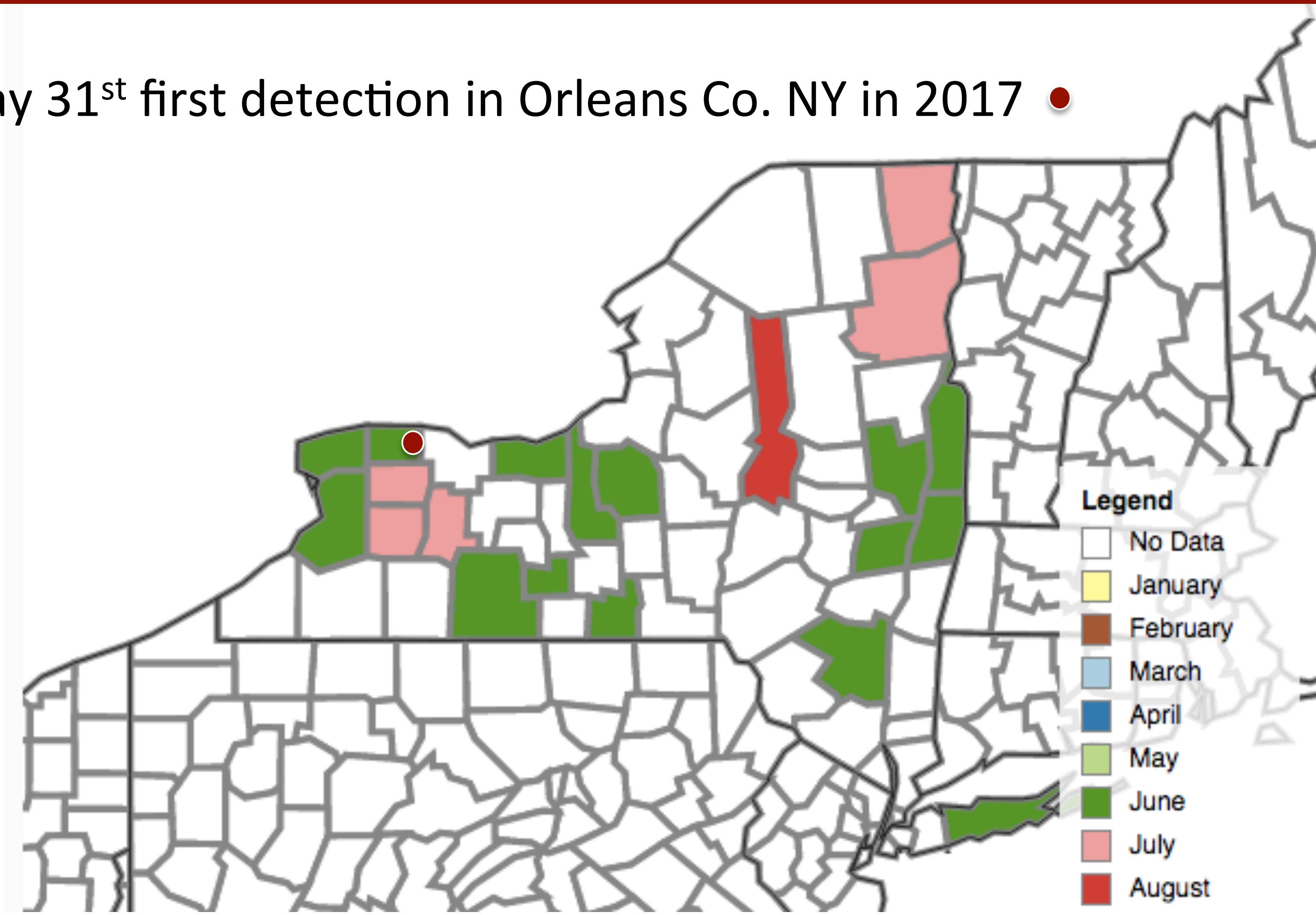
SWD in New England - 2011

First NY detection September 11th , 2011 in NY
Mid-September Organic Raspberry
Columbia & Suffolk Counties ●



SWD in New England - 2017

May 31st first detection in Orleans Co. NY in 2017 ●

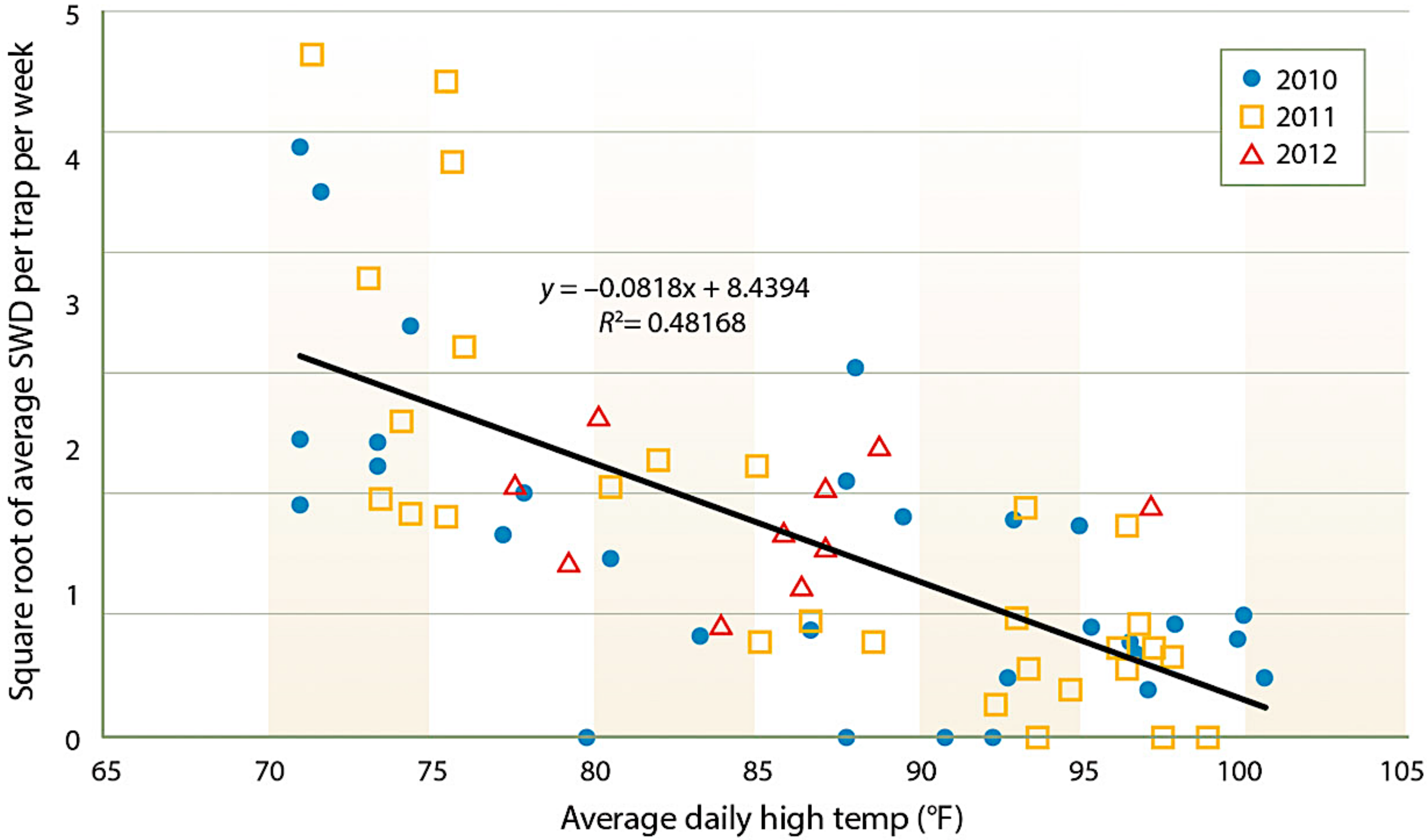


Life Cycle of the Spotted Wing Drosophila
Drosophila Suzukii (Matsumurai)

Yearly First Trap Captures

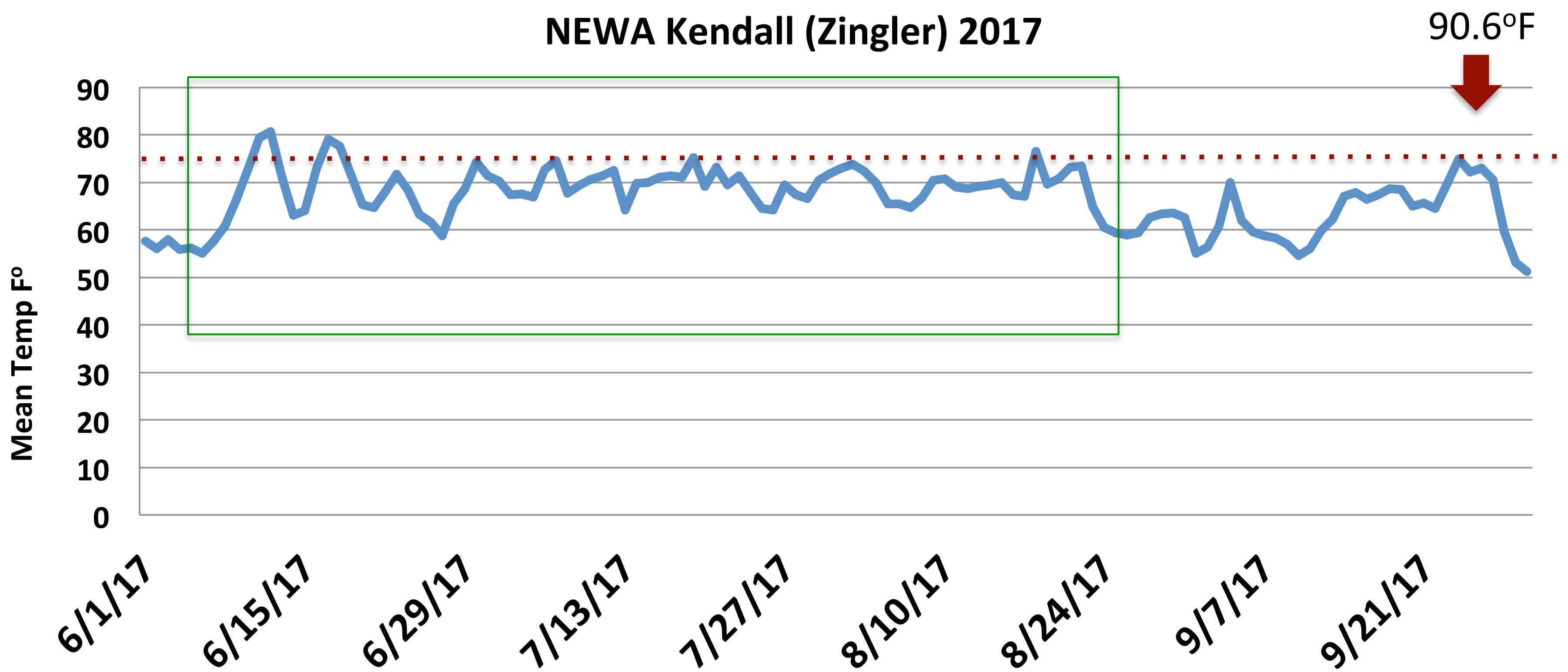
New York	Michigan
2011 – Sept. 11 (Columbia/Suffolk)	2011 – August 7
2012 – July 20 (Ulster)	2012 – June 3
2013 – June 11 (Ontario)	2013 – May 26
2014 – July 22 (Orleans)	2014 – June 15
2015 – June 22 (Orange)	2015 – June 28
2016 – July 7 (Dutchess)	2016 – June 19
2017 – May 31 (Orleans)	**2017 – May 19**
June 27 (Dutchess)	

Life Cycle of the Spotted Wing Drosophila
Drosophila suzukii (Matsumurai)



Haverland, D.R. et. al. Phenology of spotted wing drosophila in the San Joaquin Valley varies by season, crop and nearby vegetation. *California Agriculture* 70(1):24-31. https://doi.org/10.3733/ca.v070n01p24 January 01, 2016

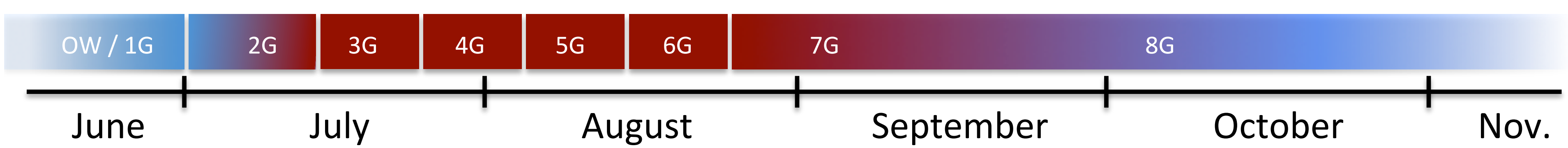
Life Cycle of the Spotted Wing Drosophila
Drosophila suzukii (Matsumurai)



Life Cycle of the Spotted Wing Drosophila
Drosophila suzukii (Matsumurai)

- Earliest 1st emergence & trap capture on 31st May (Orleans), 27th June (Dutchess), 2017
- ≥6 Generations / year
- 350 eggs per female
- Majority of the population at any time exist in the immature life stage
- Insecticides primarily target the adult stage with some activity against the egg and developing larva

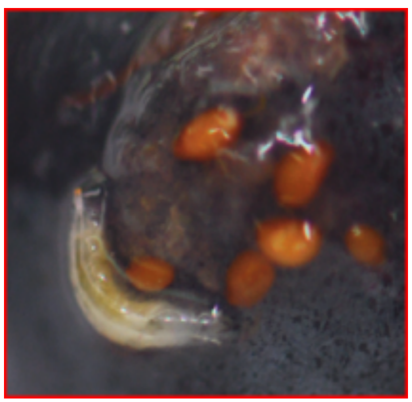
	egg	larvae	pupae	adult	egg to adult
Spring	72 hrs	7 days	15 days	30 days	25.0 days
Summer	12 hrs	5 days	4 days	20-30 days	9.5 days

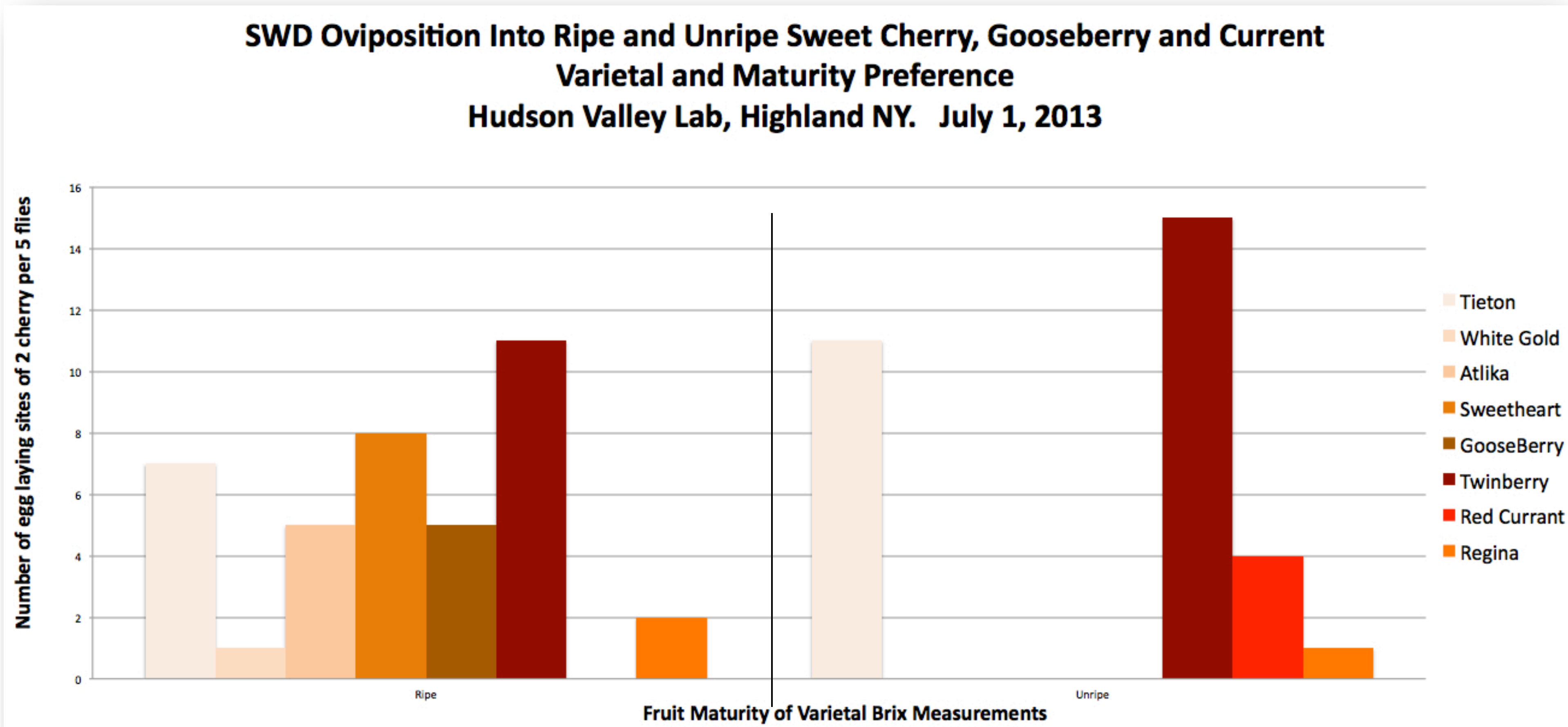


Generational Intervals

Fruit Affected by SWD

Highest risk	Moderate risk	Alternate hosts
Strawberries	Peaches	Wild plants with berries, such as…
Raspberries	**Grapes**	**Tartarian Honeysuckle**
Cherries (Tart pref.)	Pears	Snowberry
Nectarines	Apples	Elderberry
Blueberries	Tomato	Pokeweed
Blackberries		Dogwood

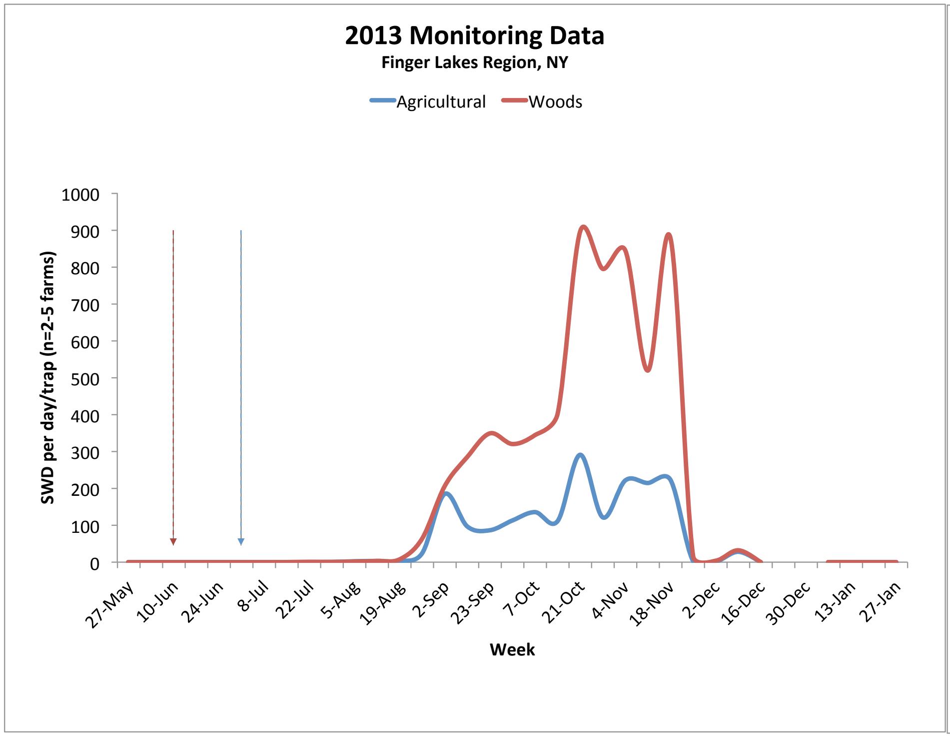


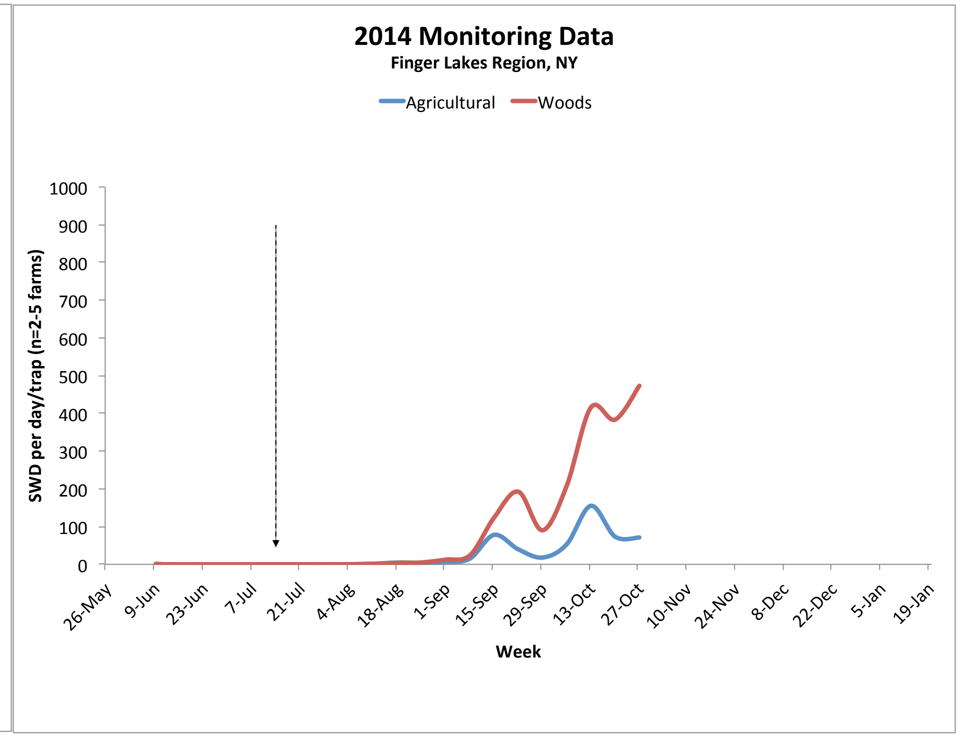
SWD oviposition during pre-harvest and ripened development.

Male and Female flies were introduced to fruit, and allowed 48 hours to oviposit before they were removed and eggs were counted.

Each fruit was isolated with 2 cherry (fruit) of each V. and 5 female SWD adults.

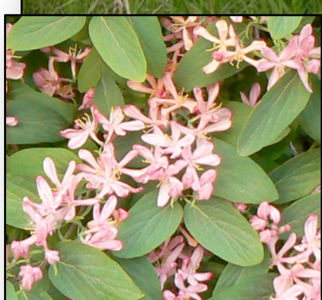
SWD SEASONAL DYNAMICS IN THE NORTHEAST





Credit: Greg Loeb Lab, NYSAES Geneva, NY

SWD Attract and Kill Management 2015

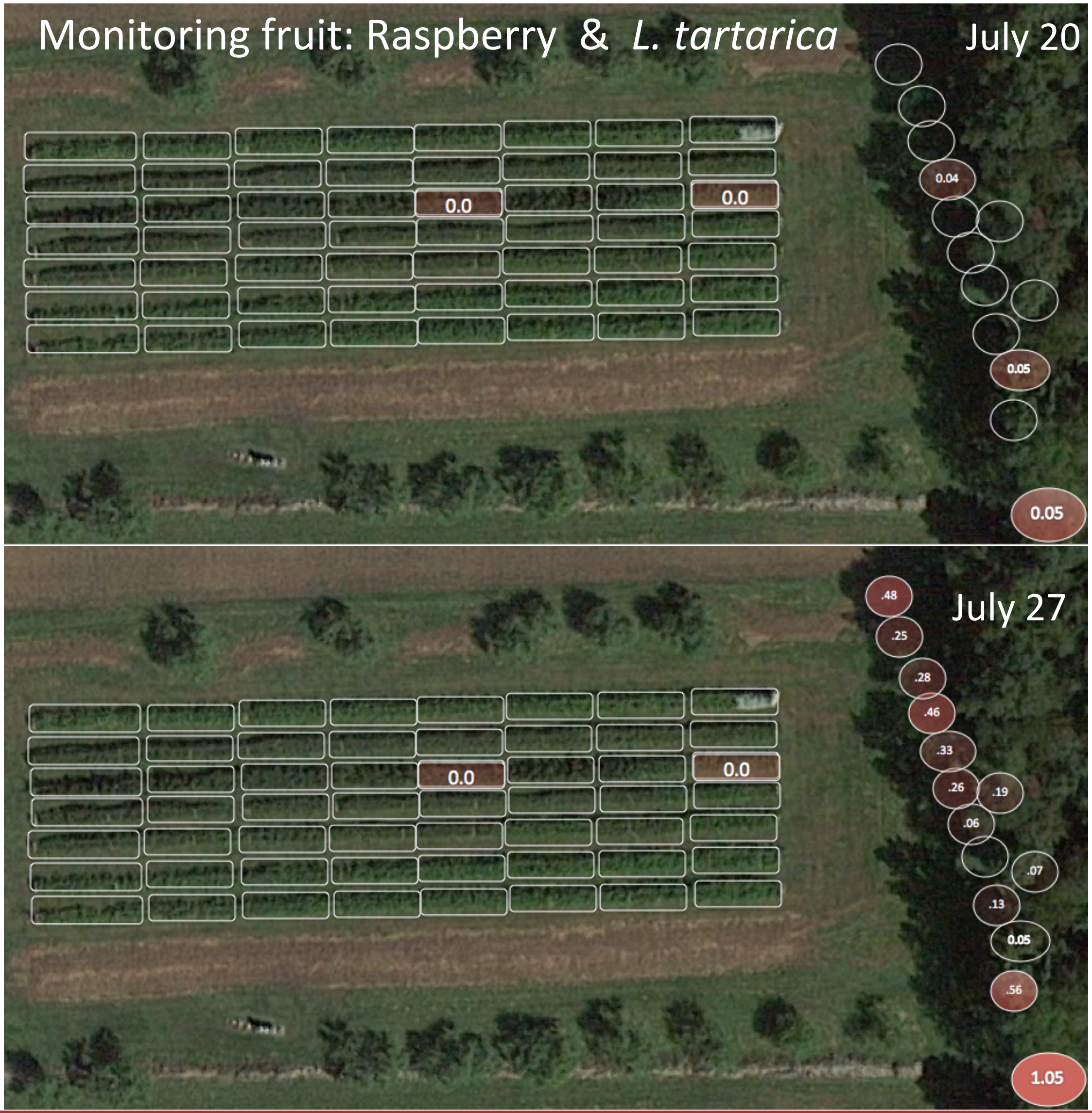


Honeysuckle is a primary host for SWD; *L. tartarica* fruit favored over raspberry in June-August.

Begin to build in high numbers then move from alternate host to crops.

Potential for use as management sites using biological control and attract and kill for SWD in alternate hosts.

SWD Attract and Kill Management 2015

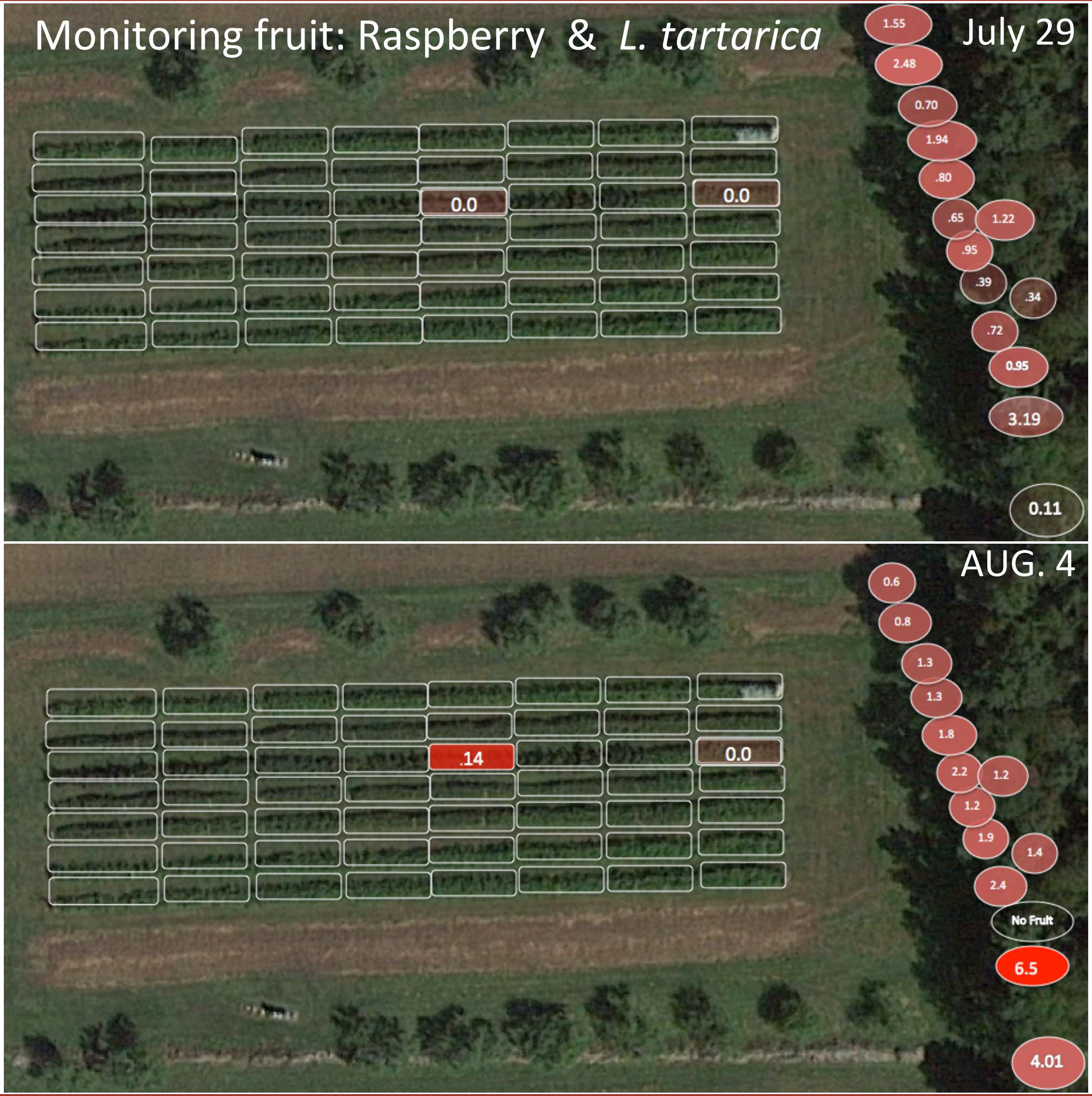


WestWind Farm, Accord NY

- First SWD eggs found in *L. tartarica* on 20 July

- SWD populations build over several weeks prior to migration to commercial fruit.

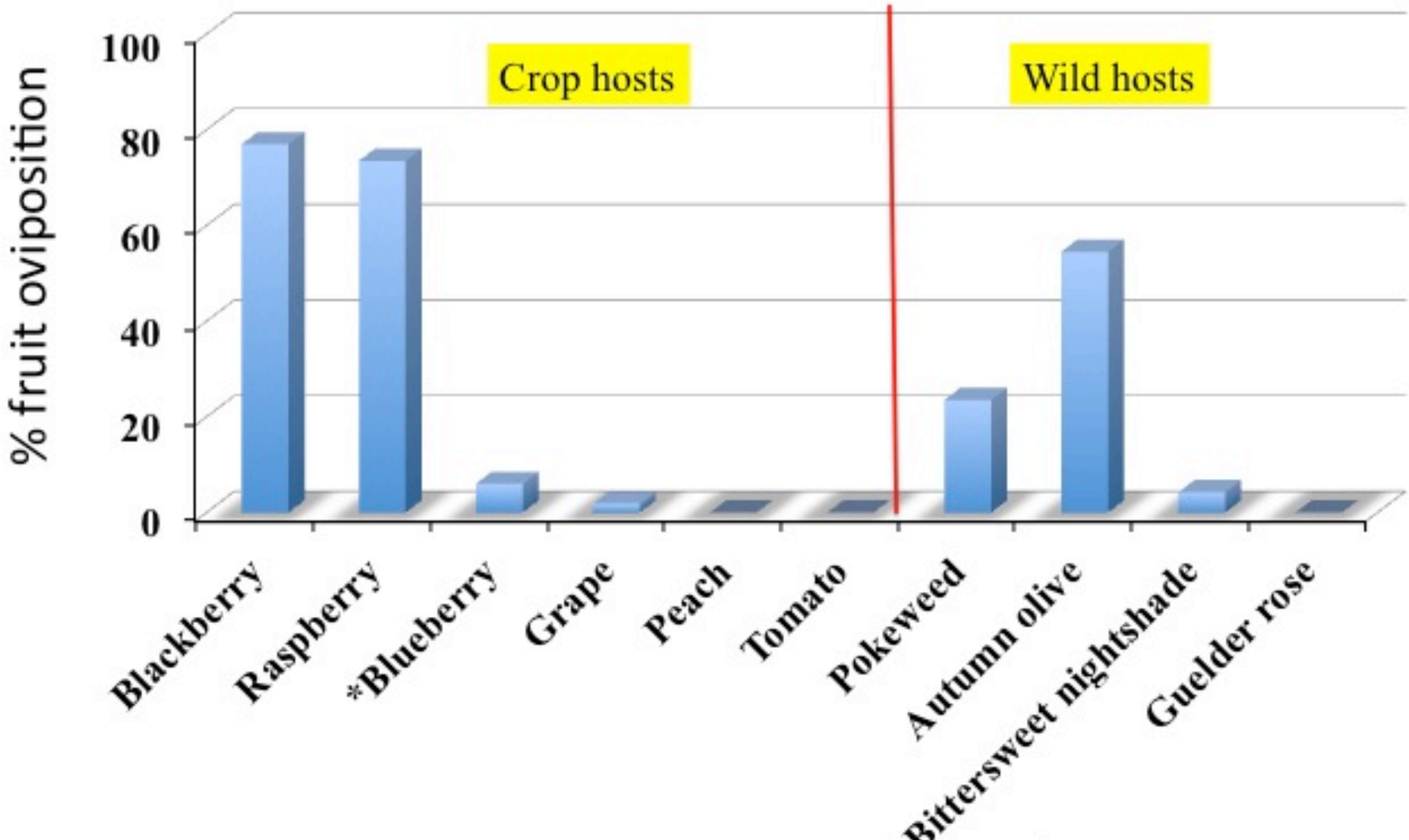
SWD Attract and Kill Management 2015



WestWind Farm

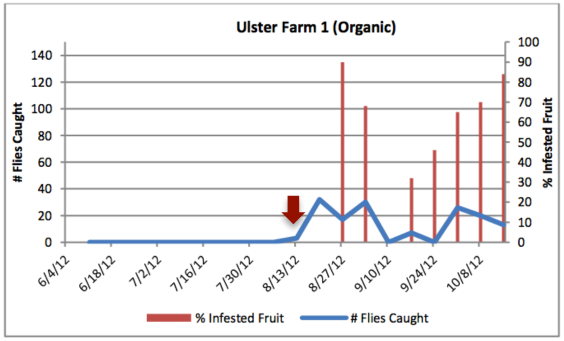
- First SWD eggs found in raspberry on 4 August.
- Raspberry collections taken through to the end of season.

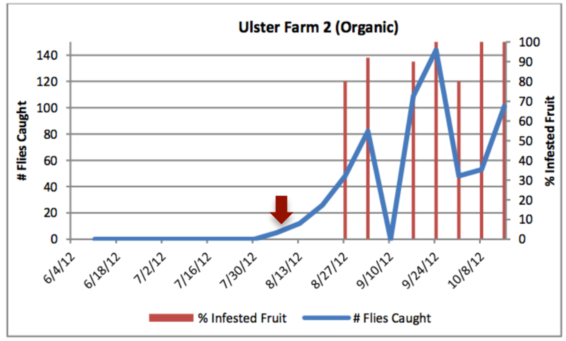
Fruit and wild berries oviposited or egg laid by SWD -2012

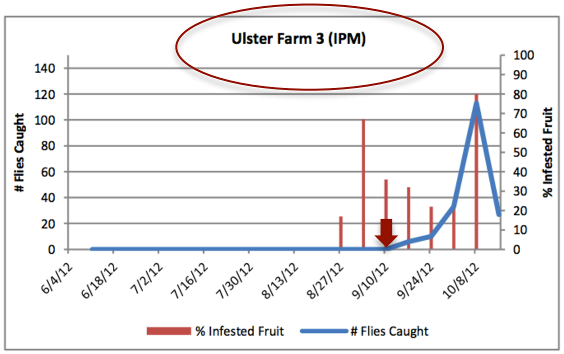


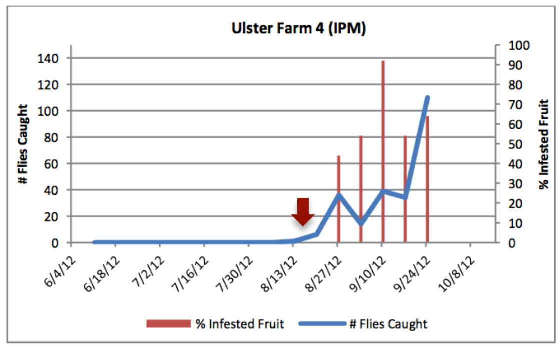
Data from F. Zaman, 2012

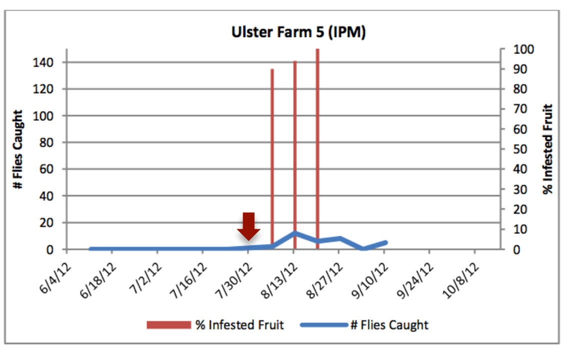
Monitoring SWD Using ACV on 6 Farms in the Hudson Valley Eastern, NY - 2012

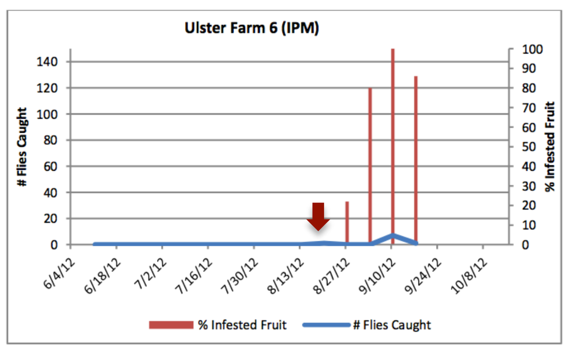












Fruit Monitoring & Injury

- SWD oviposition may precedes adult trap captures in production systems.
- Newer traps have increased sensitivity to adult presence
- Conventional and organic production systems contain raspberry fruit with SWD eggs & larva.

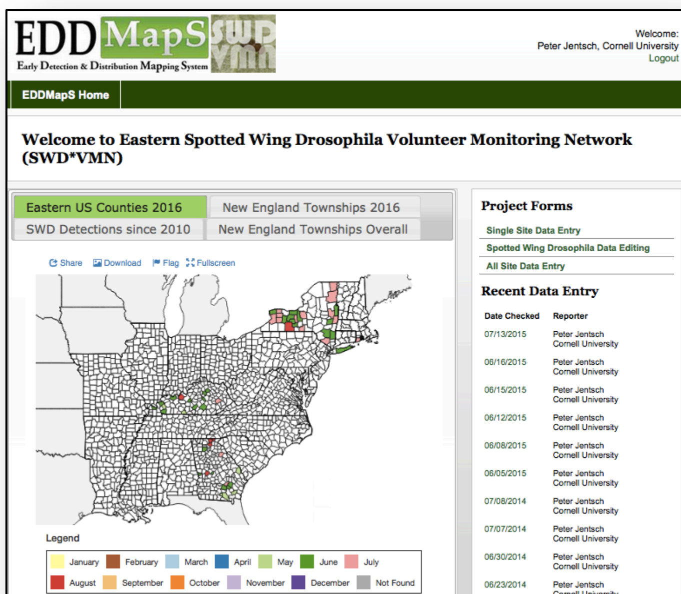
Sampling and Monitoring Protocols

Monitoring: Set traps in late May along wooded / hedgerow edge of crop
Check traps weekly for adult fly. (Scentry SWD trap and lure; $15.00 ea.)

Extension Outreach: EDDMaps for first trap capture

Sampling: Sample 25 fruit from each of 4 edge plants to observe 1st eggs in fruit

Application: Begin at 1st observation of egg laying.



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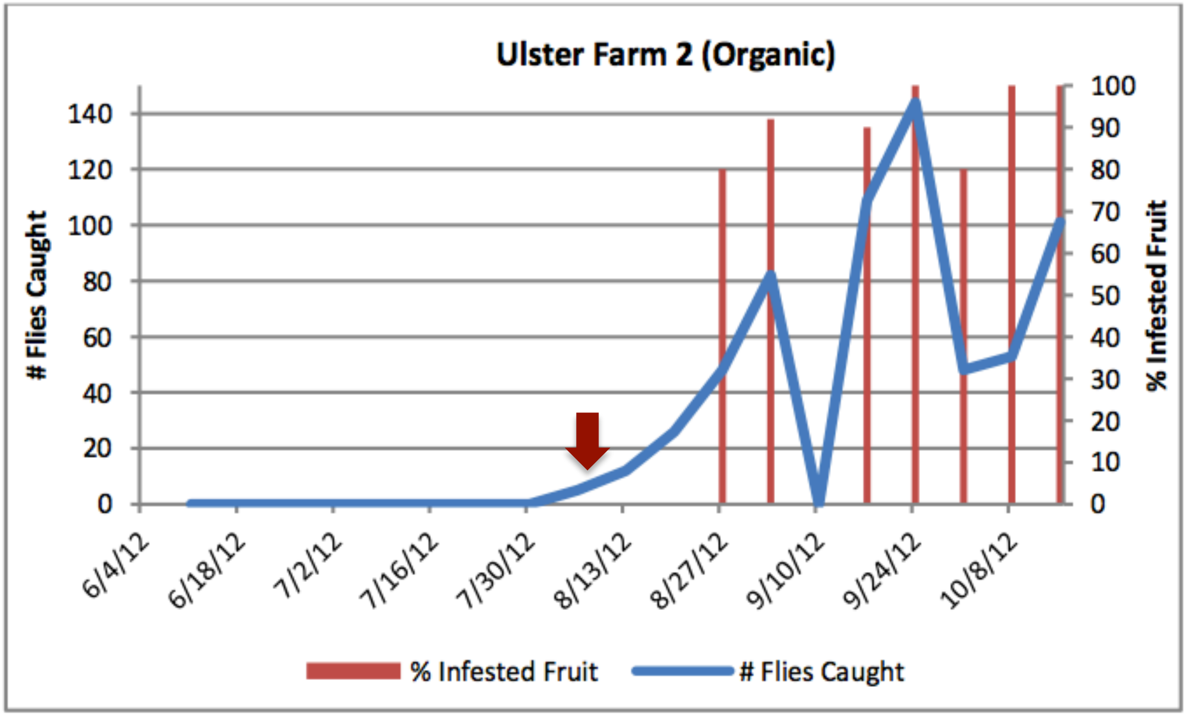

Monitoring & Fruit Injury

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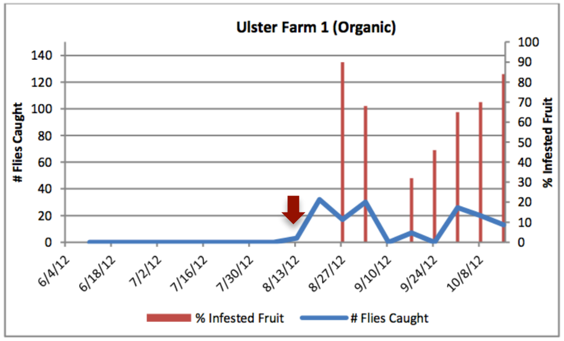
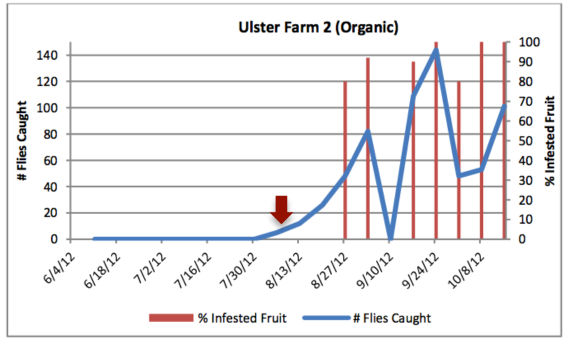
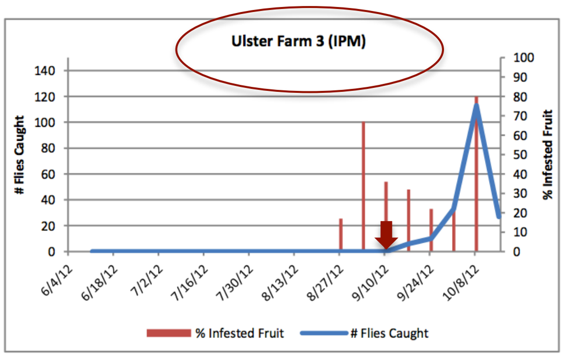
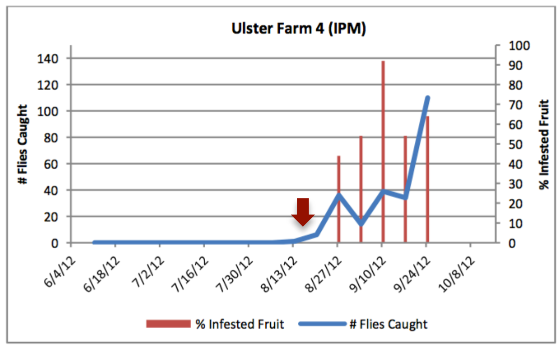
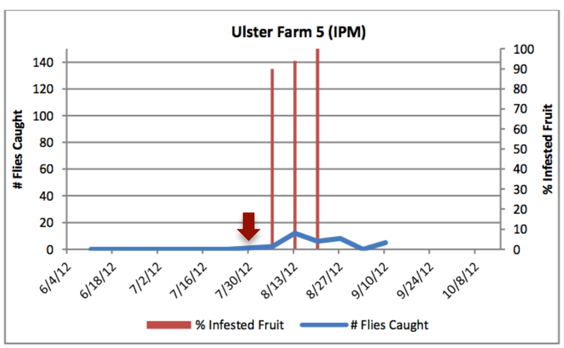
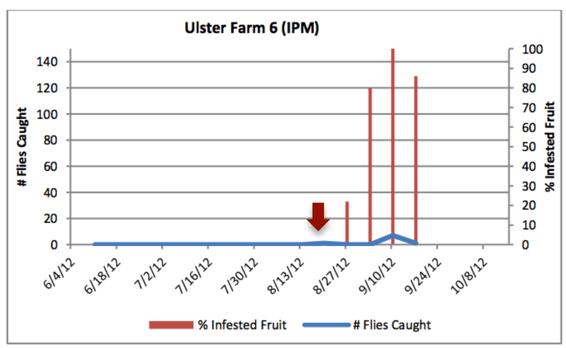












Monitoring & Fruit Injury

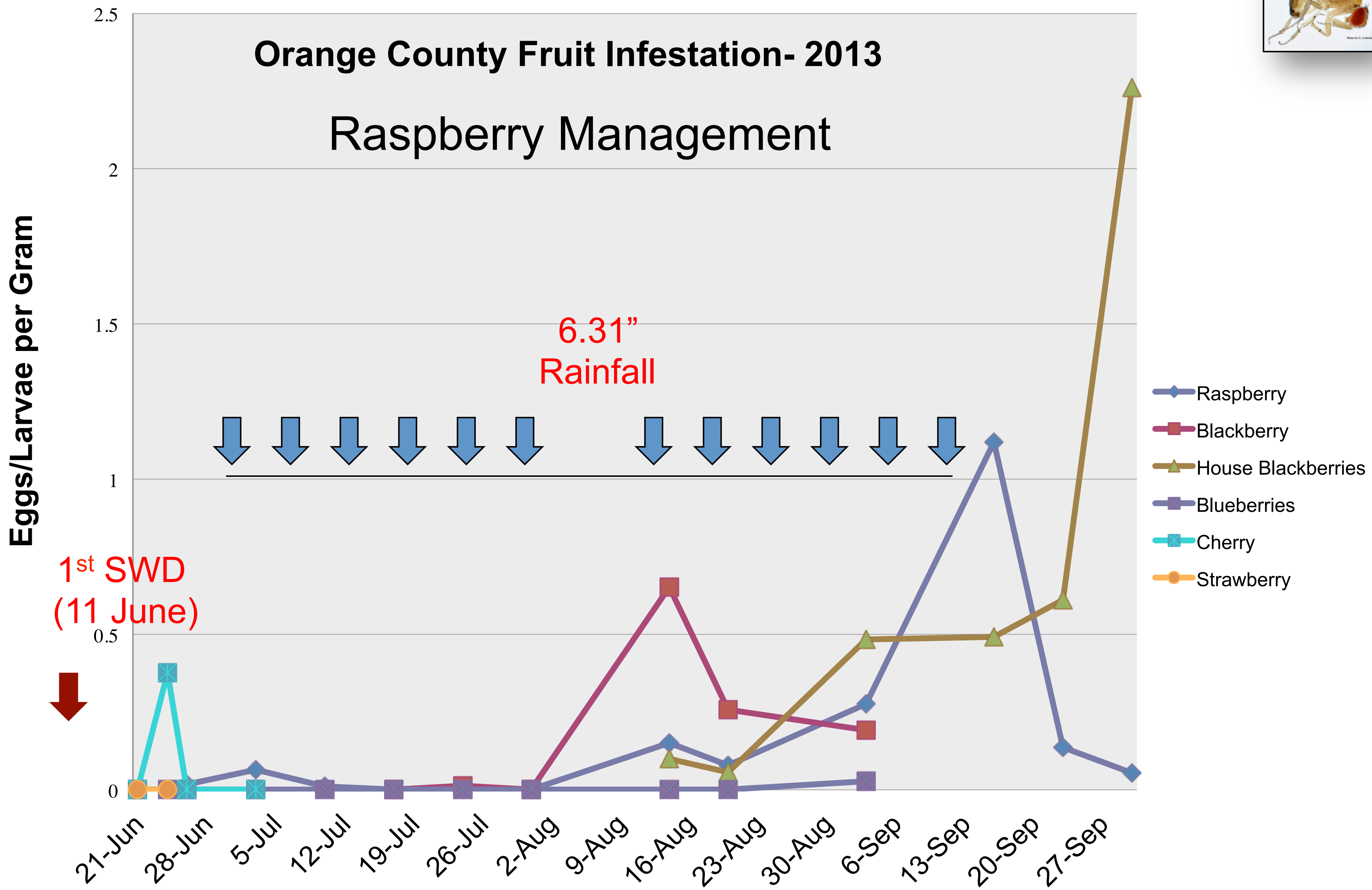
- SWD oviposition may precedes adult trap captures in production systems.
- Older traps were less attractive, allowing SWD damage prior to 1st adult trap capture.
- Newer traps have increased sensitivity to adult presence
- Both conventional and organic production systems contain raspberry fruit with SWD eggs & larva.

Managing Insecticide Resistance: Raspberry

SWD Control in Mixed Small Fruit; Orange Co. 2012
Pick-Your Own Program

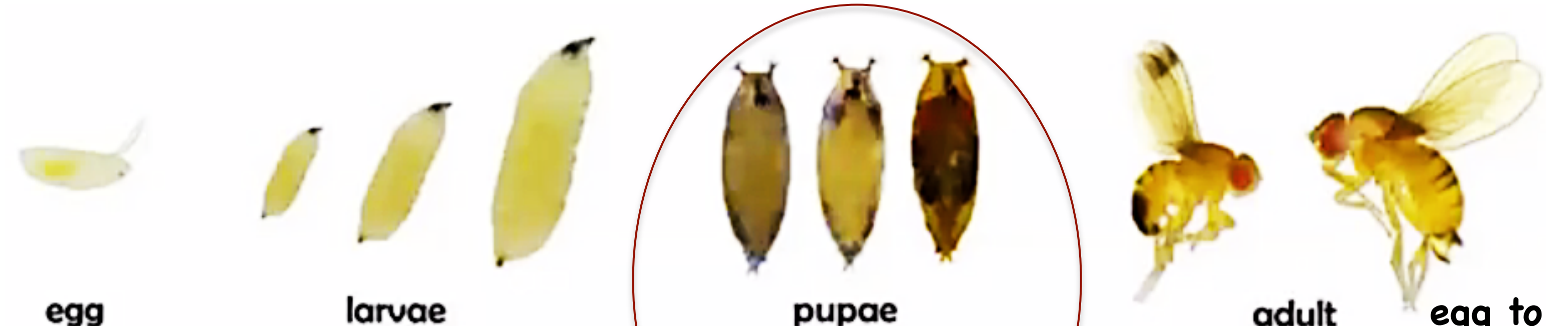
Date	Material	Rate	Commodity
27 June	Malathion 57	2 pts./A	Raspberry
1 July	Assail 30SG	5 oz./A	Raspberry
5 July	Malathion 57	2 pts./A	Raspberry
12 July	Delegate 25WDG	3 oz./A	Raspberry
14 July	Brigade	8 oz./A	Raspberry
19 July	Assail 30SG	5 oz./A	Raspberry
22 July	Danitol	16 oz./A	Raspberry
27 July	Mustang Max	4 oz./A	Raspberry
30 July	Assail 30SG	5 oz./A	Raspberry
	6.31" Rainfall; 6 day application interval		
5 August	Delegate 25WDG	3 oz./A	Raspberry
19 August	Brigade	8 oz./A	Raspberry

Managing Insecticide Resistance: Raspberry



Life Cycle of the Spotted Wing Drosophila
Drosophila suzukii (Matsumurai)

- Earliest 1st emergence & trap capture on 22nd June, 2017
- ≥6 Generations / year
- 350 eggs per female
- Majority of the population at any time exist in the immature life stage
- **80% of pupa fall to the ground from fruit (blueberry); partially buried**



	egg	larvae	pupae	adult	egg to adult
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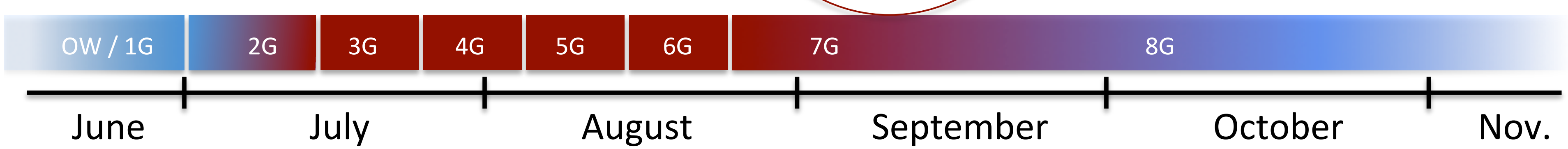


Generational Intervals

Biological Control of Spotted Wing Drosophila

Most SWD pupae drop from the fruit and reside in the top 0.5 cm layer of soil.

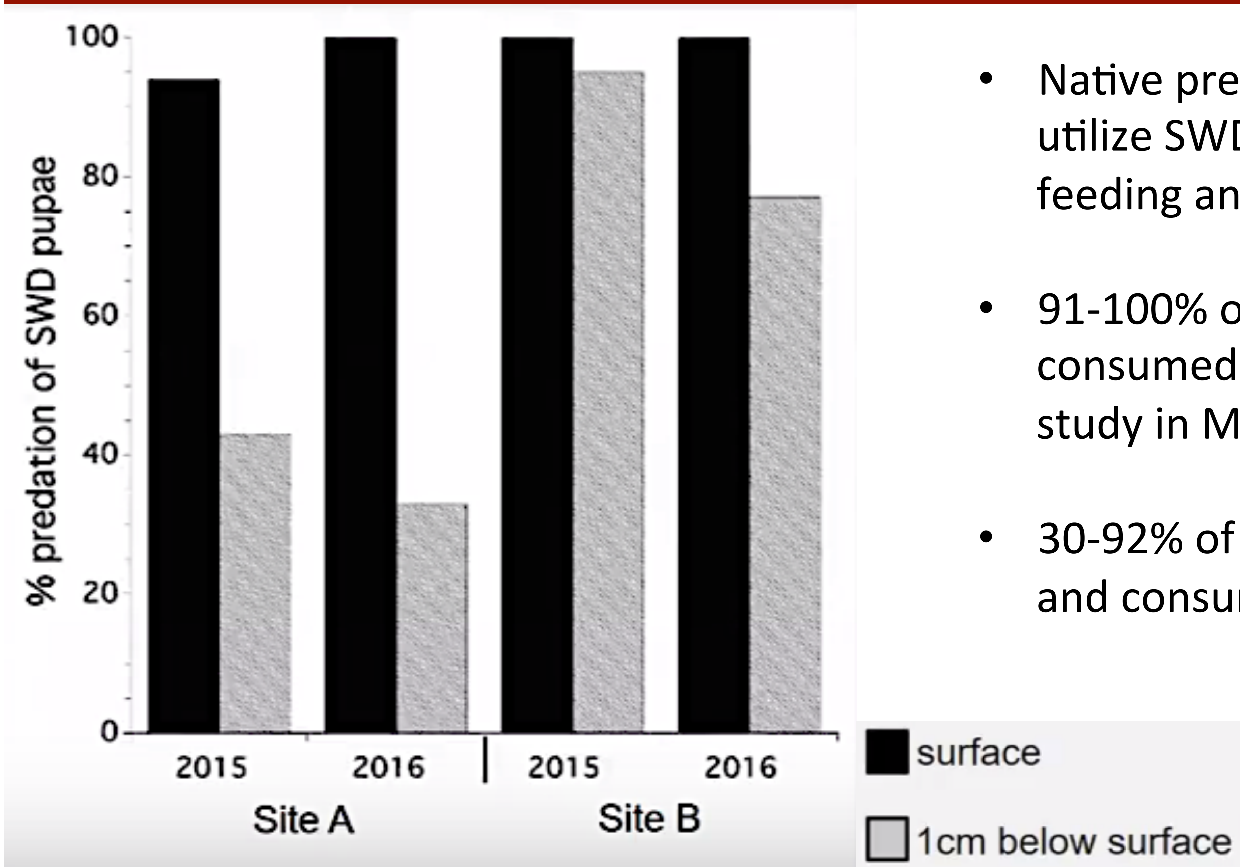
Predators of SWD include:
Ground beetle species (Carabidae)
Field crickets (*Gryllus pennsylvanicus* Burmeister)
Ants
Harvestmen

Pupal predation rates in wild field blueberry were high, with higher rates of predation on exposed pupae compared to buried pupae.

Laboratory studies confirmed that ground beetles and field crickets are likely predators of D. Suzukii pupae.

J Econ Entomol. 2017 Dec 5;110(6):2308-2317. doi: 10.1093/jee/tox233.
Pupation Behavior and Predation on Drosophila Suzukii (Diptera: Drosophilidae) Pupae in Maine Wild Blueberry Fields.
Ballman ES[1], Collins JA[1], Drummond FA.

Biological Control of Spotted Wing Drosophila: Predator Feeding on SWD Pupa



- Native predators, native & Asian parasitoids utilize SWD larva and pupa as resources for feeding and reproduction.
- 91-100% of surface SWD pupa were consumed by predators in a wild blueberry study in Maine.
- 30-92% of buried SWD pupa were removed and consumed by predators.

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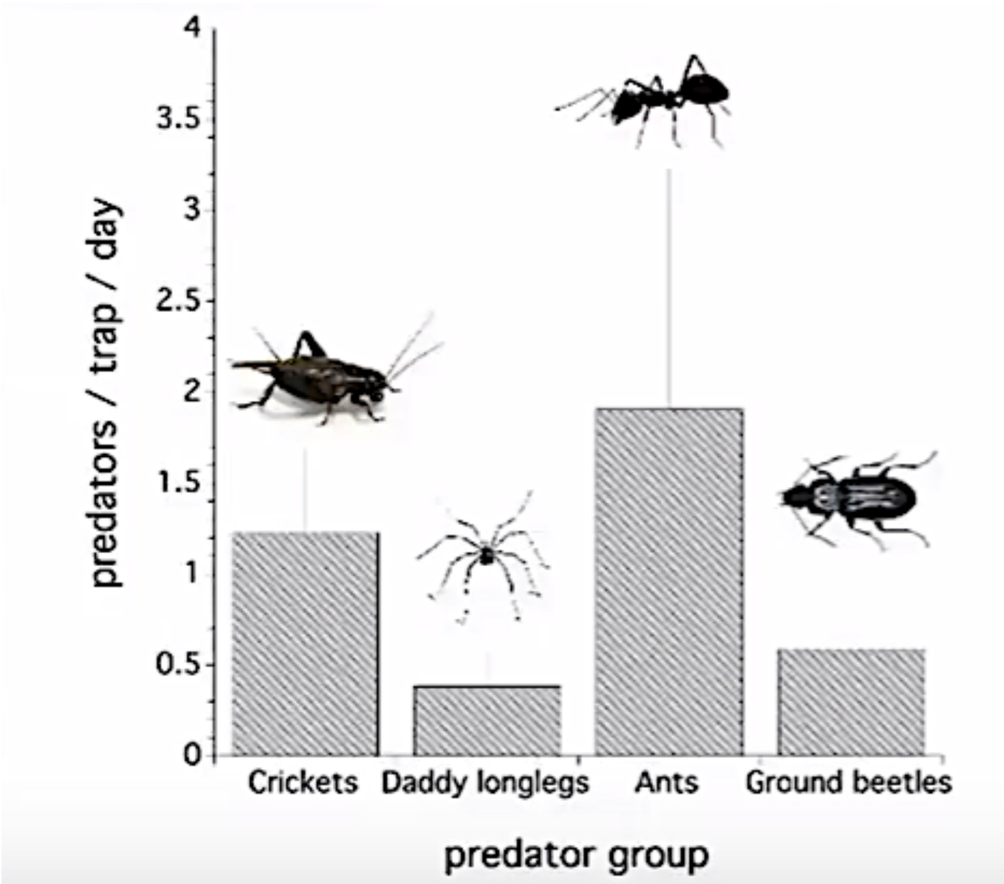

In wild blueberry

- 61-91% of SWD Pupa removed by predation
- Ants remove and carry off pupa from soil

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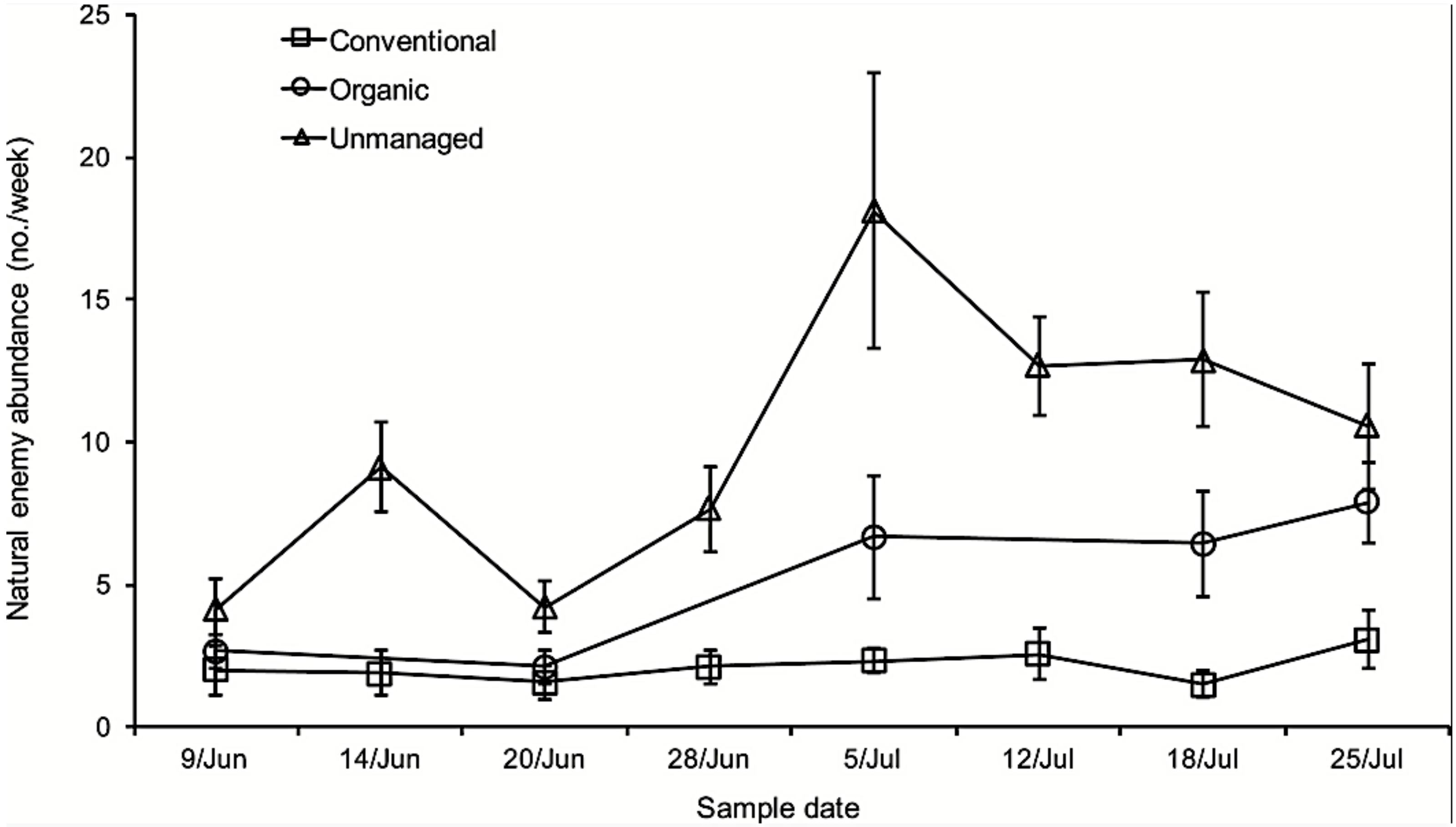
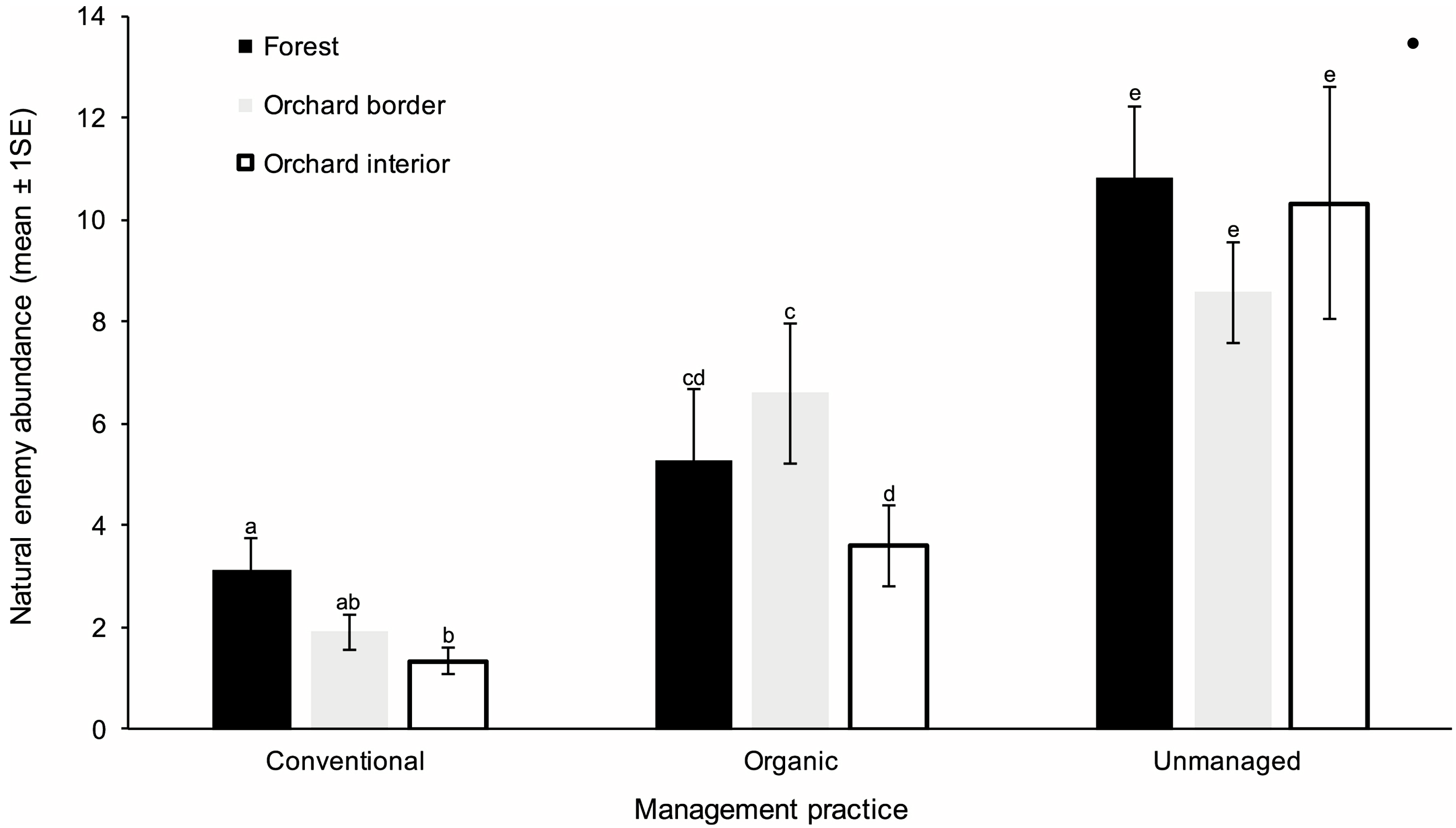
Biological Control of Spotted Wing Drosophila



Seasonal mean (±1 SE**) natural enemy abundance** from suction samples pooled across transect and site to over time. Symbols represent corresponding management practice collected during the blueberry growing and harvest season.

Natural Enemy Abundance in Southeastern Blueberry Agroecosystems: Distance to Edge and Impact of Management Practices. T Seth Whitehouse Ashfaq A Sial Jason M Schmidt. *Environmental Entomology*, Volume 47, Issue 1, 8 February 2018, Pages 32–38, https://doi.org/10.1093/ee/nvx188 23 December 2017

Biological Control of Spotted Wing Drosophila



- 60% of pupa consumed in unmanaged plots

Georgia: Seasonal mean (±1 SE**) natural enemy abundance** from suction samples pooled across transect and site to over time. Symbols represent corresponding management practice collected during the blueberry growing and harvest season.

Natural Enemy Abundance in Southeastern Blueberry Agroecosystems: Distance to Edge and Impact of Management Practices. T Seth Whitehouse Ashfaq A Sial Jason M Schmidt. *Environmental Entomology*, Volume 47, Issue 1, 8 February 2018, Pages 32–38, https://doi.org/10.1093/ee/nvx188 23 December 2017

Biological Control of Spotted Wing Drosophila: Native Parasitoid Wasp Species

Larval parasitoids

Leptopilina boulardi

Leptopilina heterotoma

Leptopilina clavipes

Pupal parasitoids

Pachycrepoideus vindemmiae

Trichopria drosophilae

- Most SWD parasitism occurs in the non-crop environment
- SWD is highly resistant to parasitism.
- Larva & pupa can wall off the parasite egg by encapsulation (melanin)

****

- Collections of Asian parasitoids held in quarantine have demonstrated greatest specificity and highest potential for SWD biological control

Biological Control of Spotted Wing Drosophila

Family	Parasitoid species	Host	Country
Braconidae	***Asobara japonica***	SWD, other drosophilids	SK, CHN
	Asobara leveri	SWD, other drosophilids	SK, CHN
	Asobara brevicauda	SWD	SK
	Asobara triangulata	SWD	SK
	Asobara mesocauda	SWD	SK, CHN
	Asobara unicolorata	SWD	CHN
	Asobara spp.	SWD	CHN
Figitidae	***Ganaspis brasiliensis***	SWD	SK, CHN
	Leptopilina japonica	SWD	SK, CHN
	Leptopilina formosana	SWD, other drosophilids	SK
	Leptopilina boulardi	Other drosophilids	SK
	Leptopilina spp.	SWD	CHN
Pteromalidae	*Pachycrepoideus vindemiae*	Other drosophilids	SK
Diapriidae	*Trichopria drosophilae*	SWD, other drosophilids	SK, CHN

Chemistries for Fruit Production: SWD

Class	IRAC Code	Examples	SWD Efficacy
Organophosphates	1B	Malathion	Excellent to good
Pyrethroids	3A	Brigade, Danitol, Mustang Max	Excellent
Spinosyns	5	Delegate, Entrust	Excellent to good
Neonicotinoids	4A	Assail	Good to poor
Carbamates	1A	Sevin	Good to poor
Diamide	28	Exirel*	Excellent to good

June 2017 - Labeled Insecticides for Control of Spotted Wing Drosophila in New York Tree Fruit and Grapes – Quick Guide

Compiled by Art Agnello, Peter Jentsch, Greg Loeb, Tess Grasswitz & Juliet Carroll. Updated regularly.

Most tree fruit crops, especially apples, are currently considered at low risk of SWD infestation.
APPLES & PEARS – refer to the Cornell Guidelines for Commercial Tree Fruit Production, http://ipmguidelines.org/.

SWEET & TART CHERRY

PRODUCT	AI[1]	IRAC group[2]	EPA#	RATE/A	REI[3]	DTH[4]	Max Prod/A/yr (ai)	Total applic's	Spray Interval	Probable efficacy	
^@@Entrust 80WP Naturalyte (2ee)[a]	spinosad	5	62719-282	1.25-2.5 oz	4 hr	7 d	9 oz (0.45 lb)	refer to label	> 7 d	Good to Excellent#	✔
^@@Entrust 2SC (2ee)[a]	spinosad	5	62719-621	4-8 fl oz	4 hr	7 d	29 fl oz (0.45 lb)	refer to label	> 7 d	Good to Excellent#	✔
@@Delegate WG (2ee)	spinetoram	5	62719-541	4.5-7 oz	4 hr	7 d	28 oz (0.438 lb)	4	> 7 d	Moderate#	
*Exirel	cyazypyr	28	352-859	13.5-20.5 fl oz	12 hr	3 d	61.5 fl oz (0.4 lb)	3	> 7 d	Excellent	✔
*Asana XL (2ee)	esfenvalerate	3	352-515	4.8-14.5 fl oz	12 hr	14 d	72.7 fl oz (0.375 lb)	refer to label	-	Good to Excellent	✔
*Danitol 2.4EC	fenpropathrin	3	59639-35	10.66-21.33 fl oz	24 hr	3 d	42.66 fl oz (0.8 lb)	2	> 10 d	Excellent	✔
*Lambda-Cy EC (2ee)	lambda-cyhalothrin	3	70506-121	5.12 fl oz	24 hr	14 d	*25.6 fl oz (0.2 lb)	5 total, 4 post bloom	> 5 d	Good to Excellent	✔
*Mustang Maxx Insecticide (2ee)	zeta-cypermethrin	3A	279-3426	4 fl oz	12 hr	14 d	24 fl oz (0.15 lb)	6	> 7 d	Excellent	✔
^#Grandevo	*Chromobacterium subtsugae* strain PRAA4-1 and spent fermentation media	UN	84059-27	2-3 lb	4 hr	0 d	-	-	≤ 7 d	Fair to Poor	
Tart Cherry Only											
*Imidan 70W	phosmet	1B	10163-169	2.13 lb	72 hr	7 d	7.5 lb (5.25 lb)	3	-	Excellent	✔

[a] In organic production, Entrust must be rotated with insecticides with different modes of action, consider using Grandevo or products containing the active ingredients azadirachtin or pyrethrin.

*Refer to label for details and additional restrictions.
#Adding sugar (sucrose) at 2 lb/100 gal water as a feeding stimulant will increase efficacy.
^Approved for organic use in NY.
@After two consecutive applications must rotate to different mode of action.
@@ After three consecutive applications must rotate to different mode of action.

[1] Active Ingredient.
[2] Mode of Action, based on IRAC group code (UN = unknown).
[3] Re-entry Interval (hr = hours).
[4] Days to Harvest (PHI) (d = days).

New Chemistries for Fruit Production: SWD

Exirel®

Spotted Wing Drosophila Management in Blueberry
Dr. John Wise, Michigan State 2013

Product	Application interval (in days)	SWD larvae/lb fruit
Exirel™ 13.5 fl. oz./A+ NIS	7	3.8 d
Exirel™ 16.9 fl. oz./A+ NIS	7	6.2 d
Exirel™ 16.9 fl. oz./A+ NIS	14	11.9 bcd
Delegate 25 WG 6 oz./A+ NIS	14	24.9 ab
Untreated	N/A	31.9 a

Survey on insecticide efficacy against SWD, collated by Rufus Isaacs, MSU November, 2013

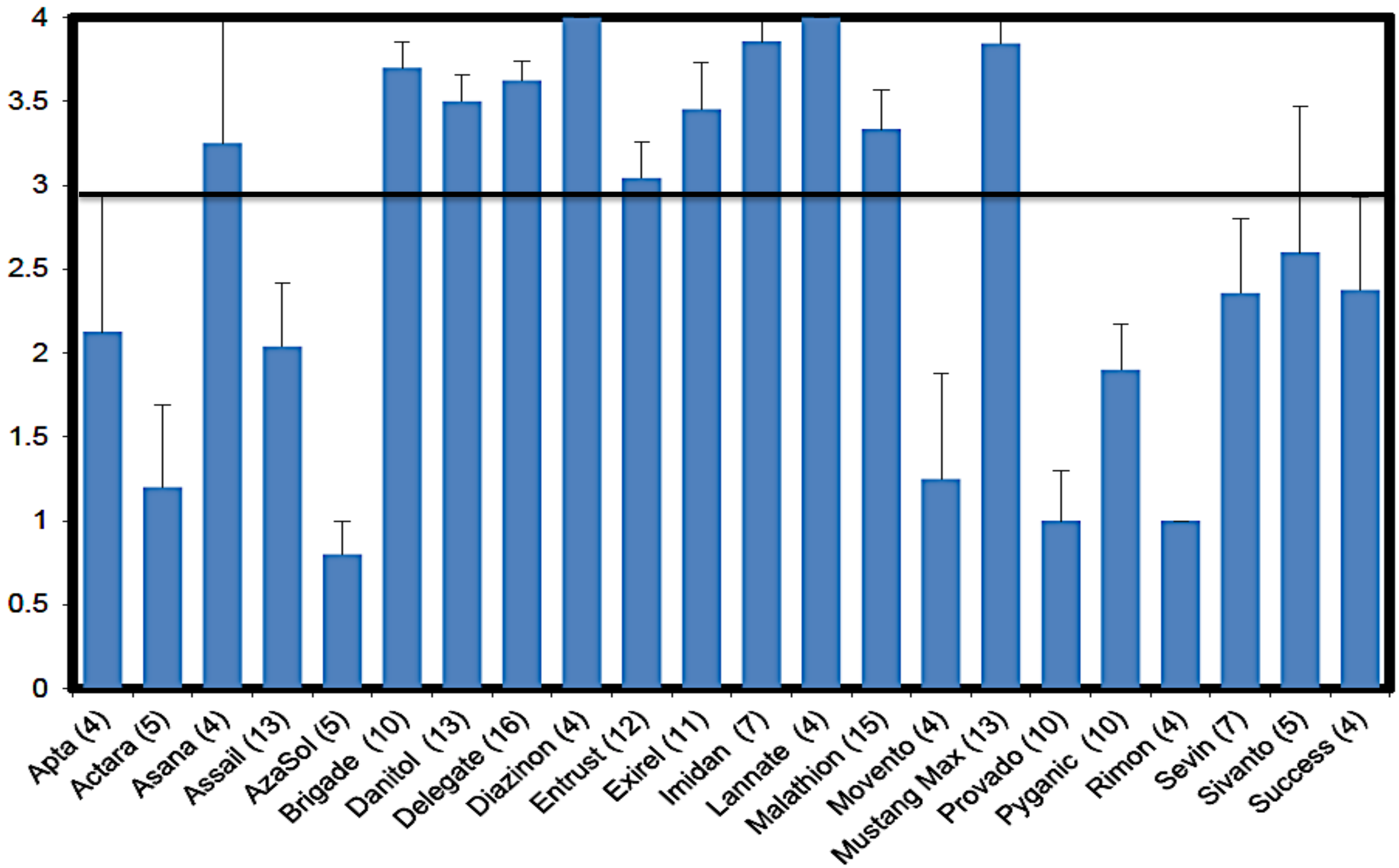


Figure 1. Average ± S.E. efficacy rankings for 22 insecticides that have been tested against SWD in various fruit crops. Insecticides were ranked as not effective (score = 0), weakly active (1), fair (2), good (3), or excellent (4). Only insecticides that had 4 or more submitted are included in the figure, and the number of entries is shown in parentheses below the bars.

Success and Failure in West Central Michigan 2017 Cherry Production

- Growers who **stretched insecticide intervals to 9 to 10 days**, particularly within two weeks of harvest, had **larval contamination**.
- Growers that stretched **excellent products seven to eight days did not have contamination** this season.
- No grower had contamination at harvest when insecticides were applied every **eight days or less, if the product choice was excellent.**
- Products outside of the excellent rating that were **stretched seven or more days resulted in contaminated fruit**.

Larry Gut, Feb. 8th, 2018 Horticultural Days - Southwest Michigan Lake Michigan College, Mendel Center, Benton Harbor, MI

Success and Failure in West Central Michigan 2017 Cherry Production

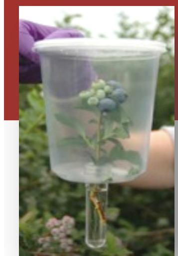
- **Successful control of SWD:** Applications began about three weeks before predicted harvest, keeping tight intervals (six to eight days) using excellent rated insecticides. Consideration for re-application of insecticide shortly after rain events.

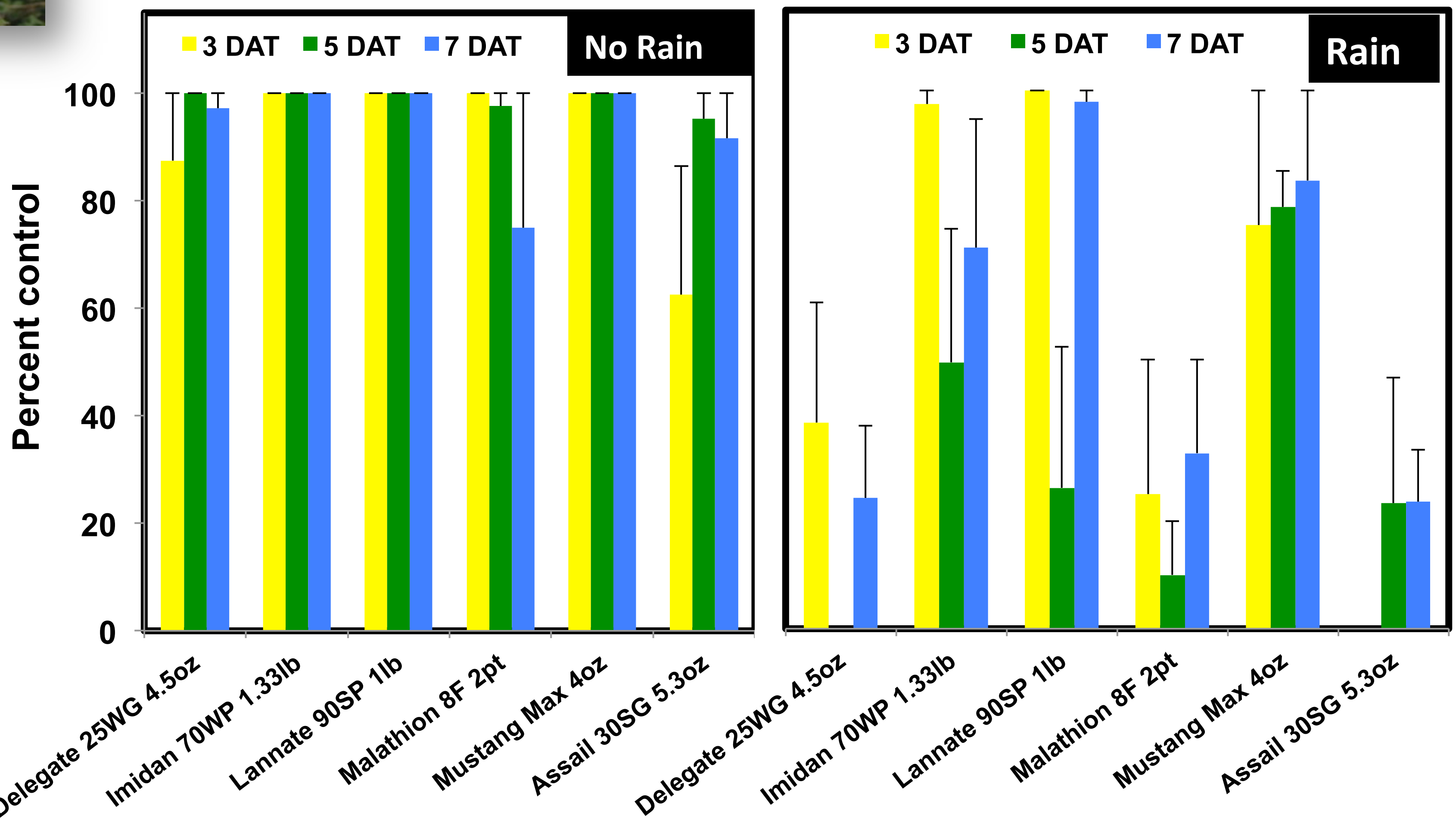
- **Failure: Growers beginning 'early',** four weeks from harvest and trying to stretch the same number of sprays further to keep costs down, suffered SWD larval contamination.

Larry Gut, Feb. 8th, 2018 Horticultural Days - Southwest Michigan Lake Michigan College, Mendel Center, Benton Harbor, MI

Effect of Rain on Some Common Insecticides in Blueberry

From Rufus Isaacs, MSU





0.8 inches of rain on treated bushes
1 day after application

MICHIGAN STATE UNIVERSITY

SUMMARY

- Insecticides are presently the primary method of control for SWD
- Choose insecticide with excellent efficacy ratings to manage SWD
- Consider insecticide rainfastness and weather forecasts to optimize SWD management
- Reapply insecticide within 24hr. to maintain residual activity after rain events

Rainfastness of insecticides

- **Several factors influence impact of precipitation on a pesticide's performance.**

- First is the **plant-penetrative attributes** of the various compounds.

- Some pesticide chemistries, like **organophosphates**, have limited penetrative potential in plant tissue, and thus are considered primarily as surface materials.

- Some compounds, such as **carbamates, oxadiazines and pyrethroids**, penetrate plant cuticles, providing some resistance to wash-off.

Rainfall influences performance of insecticides on the codling moth (Lepidoptera: Tortricidae) in apples. John C. Wise,1 Daniel Hulbert, Christine Vandervoort. Can. Entomol. 149: 118–128 (2017)

Rainfastness of insecticides

- **Spinosyns, diamides, avermectins** and some **Insect Growth Regulators (IGR)**, readily penetrate plant cuticles and have translaminar movement in leaf tissue.

- **Neonicotinoid** insecticides, are systemic and can have translaminar (moves from top surface to bottom of leaf) as well as acropetal movement in the plant's vascular system (moves from center to growing tips of leaves).

- **Penetration** into plant tissue is generally expected **to enhance rainfastness of pesticides**.

Rainfall influences performance of insecticides on the codling moth (Lepidoptera: Tortricidae) in apples. John C. Wise,1 Daniel Hulbert, Christine Vandervoort. Can. Entomol. 149: 118–128 (2017)

Rainfastness of insecticides

- **The second factor is the inherent toxicity of an insecticide** to the target pest and the persistence of the compound in the environment.

- In some cases, a compound may be susceptible to wash-off, but its **environmental persistence and inherent toxicity to the target pest compensates for the loss of residue, thus delaying the need for immediate re-application (Organophosphates).**

Rainfall influences performance of insecticides on the codling moth (Lepidoptera: Tortricidae) in apples. John C. Wise,1 Daniel Hulbert, Christine Vandervoort. Can. Entomol. 149: 118–128 (2017)

Rainfastness of insecticides

The third factor is the amount of precipitation.

- **Organophosphate** insecticides have the highest susceptibility to wash-off from precipitation, but following light rainfall their high field-rate toxicity to most target pests overcomes the necessity for immediate re-application.

- **Carbamate, IGR and oxadiazine insecticides are moderately susceptible to wash-off and vary widely** in their toxicity to the range of relevant fruit pests.

- **Diamide, spinosyn, avermectin and pyrethroid** insecticides have proven to be moderate to highly rainfast on most fruit crops.

- **Neonicotinoid** insecticides *are moderately susceptible to wash-off,* with residues that have moved systemically into plant tissue being *highly rainfast*, and surface residues less so.

Rainfall influences performance of insecticides on the codling moth (Lepidoptera: Tortricidae) in apples. John C. Wise,1 Daniel Hulbert, Christine Vandervoort. Can. Entomol. 149: 118–128 (2017)

Rainfastness of insecticides

Insecticide persistence, plant penetration and rainfastness rating			
Compound class	**Persistence (residual on plant)**	**Plant penetration characteristics**	**Rainfast rating**
Organophosphates	Medium - Long	Surface	Low
Carbamates	Short	Cuticle Penetration	Moderate
Pyrethroids	Short	Cuticle Penetration	Moderate - High

Insecticide persistence, plant penetration and rainfastness rating			
Compound class	**Persistence (residual on plant)**	**Plant penetration characteristics**	**Rainfast rating**
Neonicotinoids	Medium	Translaminar & Acropetal	Moderate
Oxadiazines	Medium	Cuticle Penetration	Moderate
Avermectins	Medium	Translaminar	Moderate
IGRs	Medium - Long	Translaminar	Moderate
Spinosyns	Short - Medium	Translaminar	Moderate - High
Diamides	Medium - Long	Translaminar	Moderate - High

Rainfall influences performance of insecticides on the codling moth (Lepidoptera: Tortricidae) in apples. John C. Wise,1 Daniel Hulbert, Christine Vandervoort. Can. Entomol. 149: 118–128 (2017)

Rainfastness of insecticides

- For most insecticides, a **drying time of two to six hours is sufficient to "set" the compound in or on the plant.**

- With neonicotinoids, for which plant penetration is important, drying time can significantly influence rainfastness.

- For **neonicotinoids, up to 24 hours is needed for optimal plant penetration**, thus the time proximity of precipitation after application should be considered carefully.

- Spray adjuvants, materials intended to aid the retention, penetration or spread on the plant, can also improve the performance of insecticides.

Rainfall influences performance of insecticides on the codling moth (Lepidoptera: Tortricidae) in apples. John C. Wise,1 Daniel Hulbert, Christine Vandervoort. Can. Entomol. 149: 118–128 (2017)

Rainfastness of insecticides

Blueberry insecticide precipitation wash-off re-application decision chart - spotted wing Drosophila. Expected spotted wing Drosophila control in blueberries, based on each compound's inherent toxicity to SWD, maximum residual and wash-off potential from rainfall.

Insecticides	Rainfall = 0.5 inch		Rainfall = 1.0 inch		Rainfall = 2.0 inches	
	*1 day	*7 days	*1 day	*7 days	*1 day	*7 days
Imidan	Sufficient insecticide residue	Insufficient insecticide residue	Sufficient insecticide residue	Insufficient insecticide residue	Insufficient insecticide residue	Insufficient insecticide residue
Mustang Max	Sufficient insecticide residue	Insufficient insecticide residue	Sufficient insecticide residue	Insufficient insecticide residue	Insufficient insecticide residue	Insufficient insecticide residue
Lannate	Sufficient insecticide residue	Insufficient insecticide residue	Sufficient insecticide residue	Insufficient insecticide residue	Insufficient insecticide residue	Insufficient insecticide residue
Malathion	Insufficient insecticide residue	Insufficient insecticide residue	Insufficient insecticide residue	Insufficient insecticide residue	Insufficient insecticide residue	Insufficient insecticide residue
Delegate	Insufficient insecticide residue	Insufficient insecticide residue	Insufficient insecticide residue	Insufficient insecticide residue	Insufficient insecticide residue	Insufficient insecticide residue
Assail	Insufficient insecticide residue	Insufficient insecticide residue	Insufficient insecticide residue	Insufficient insecticide residue	Insufficient insecticide residue	Insufficient insecticide residue

- Number of days after insecticide application that the precipitation event occurred.
- Insufficient insecticide residue = Insufficient insecticide residue remains to provide significant activity on the target pest, and thus re-application is recommended.
- Sufficient insecticide residue = Sufficient insecticide residue remaining to provide significant activity on the target pest, although residual activity may be reduced.

John C. Wise et al. 2017

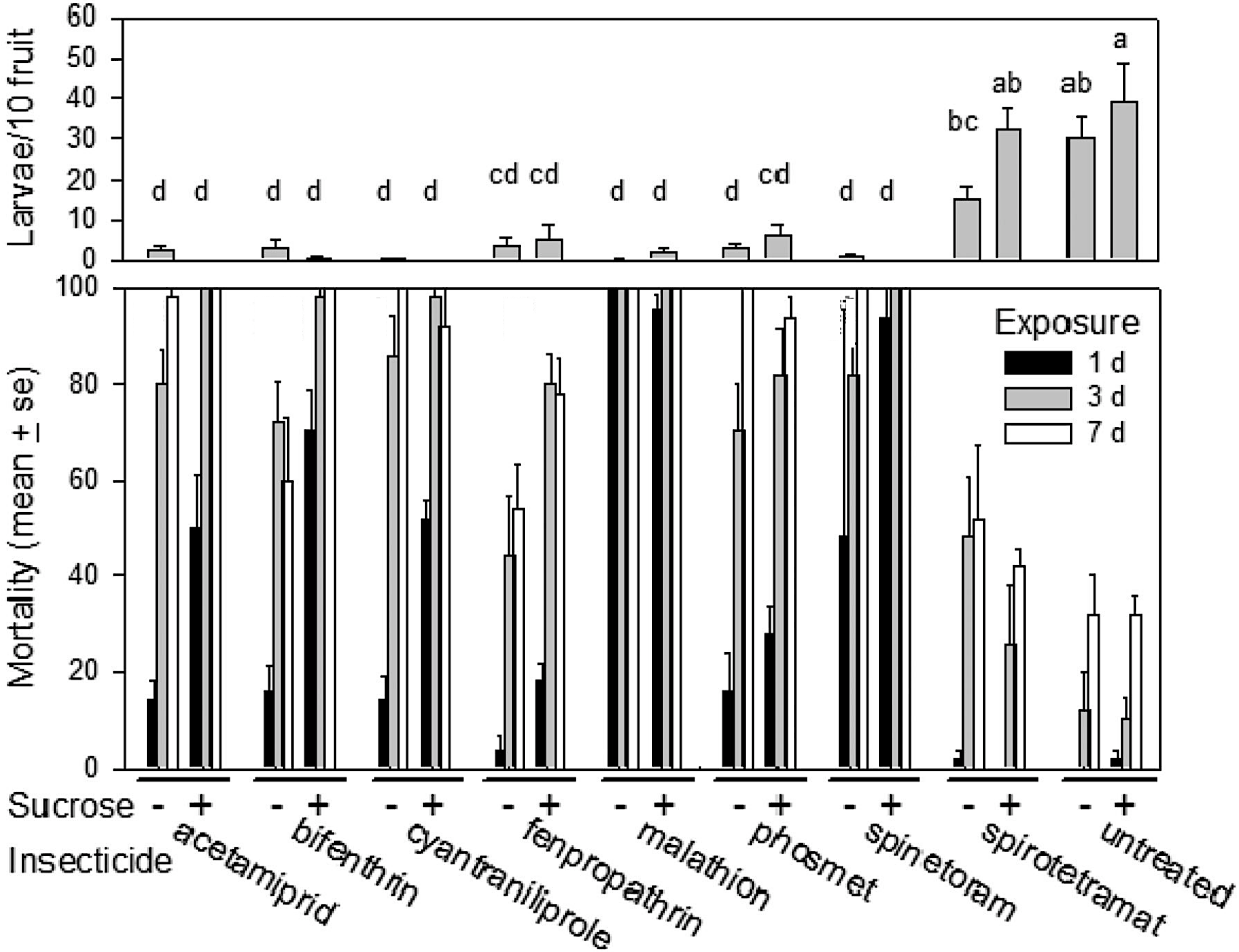
Rainfastness of insecticides

Rainfastness rating chart: General characteristics for insecticide chemical classes						
Insecticide class	**Rainfastness ≤ 0.5 inch**		**Rainfastness ≤ 1.0 inch**		**Rainfastness ≤ 2.0 inches**	
	Fruit	**Leaves**	**Fruit**	**Leaves**	**Fruit**	**Leaves**
Organophosphates	Low	Moderate	Low	Moderate	Low	Low
Pyrethroids	Moderate/High	Moderate/High	Moderate	Moderate	Low	Low
Carbamates	Moderate	Moderate/High	Moderate	Moderate	Low	Low
IGRs	Moderate	Moderate/High	Moderate	Moderate	Low	Low
Oxadiazines	Moderate	Moderate/High	Moderate	Moderate	Low	Low
Neonicotinoids	Moderate, Systemic	High, Systemic	Low, Systemic	Low, Systemic	Low, Systemic	Low, Systemic
Spinosyns	High	High	High	Moderate	Moderate	Low
Diamides	High	High	High	Moderate	Moderate	Low
Avermectins	Moderate, Systemic	High, Systemic	Low,Systemic	Moderate, Systemic	Low	Low

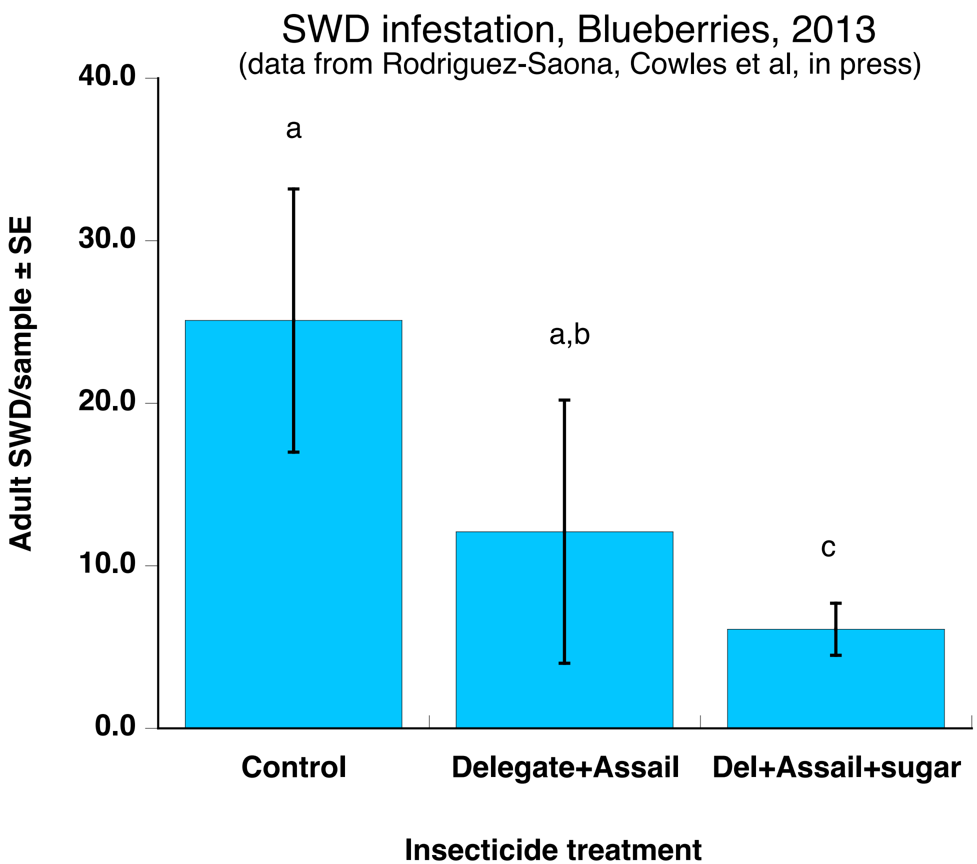
Highly rainfast = ≤ 30% residue wash-off
Moderately rainfast = ≤ 50% residue wash-off
Low rainfast = ≤ 70% residue wash-off
Systemic = Systemic residues remain within plant tissue

Sucrose Improves Insecticide Activity Against Drosophila Suzukii (Diptera: Drosophilidae)

Richard S. Cowles , Cesar Rodriguez-Saona , Robert Holdcraft , Gregory M. Loeb , Johanna E. Elsensohn , Steven P. Hesler



Enhancing Mortality with Sugar



Cultivar: ‘Bluecrop’

Treatments: 4 wk spray program
- -Alternate Delegate & Assail
- -Delegate & Assail plus sugar

Plot size: 2 rows, 32 bushes

Replicates: 4

Sugar: 2 lb. / 100 gal.

Credit: Greg Loeb Lab, NYSAES Geneva, NY

Questions??

E-mail: pjj5@cornell.edu

Thanks to the staff at the HVRL for all their support:

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Research Assistant	Christopher Leffelman
Research Assistant	Lucas Canino
Research Assistant	Ben Lee
Research Assistant	Addie Kurchin
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Farm Manager	Albert Woelfersheim
Administrative Assistant	Erica Kane
Administrative Assistant	Christine Kane
HRVL & NEWA Weather Data................................	Christopher Leffelman, Albert Woelfersheim

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NY Farm Viability Institute, NYS Orchards & Farmers (ARDP)

Developing Attract-and-kill Strategies To Manage Spotted Wing Drosophila, *Drosophila Suzukii* Matsumara, In Raspberry.

Male

Female

Cornell University

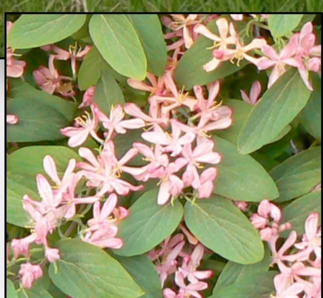
Hudson Valley Research Laboratory

Methods: Development of Attract and Kill for Management of SWD in Small Fruit

AtK Construction ($0.84 ea)

- 3” substrate woven polypropylene netting as a base
- Super Absorbent Polymer (SAP)
- Gelatin
- Red raspberry concentrate (8 mL)
- Apple cider vinegar (24 mL)
- Brewers yeast (1 g)
- 1% A.I.
- AtK solution field applied at 2 mL/disk

SWD Attract and Kill Management 2015



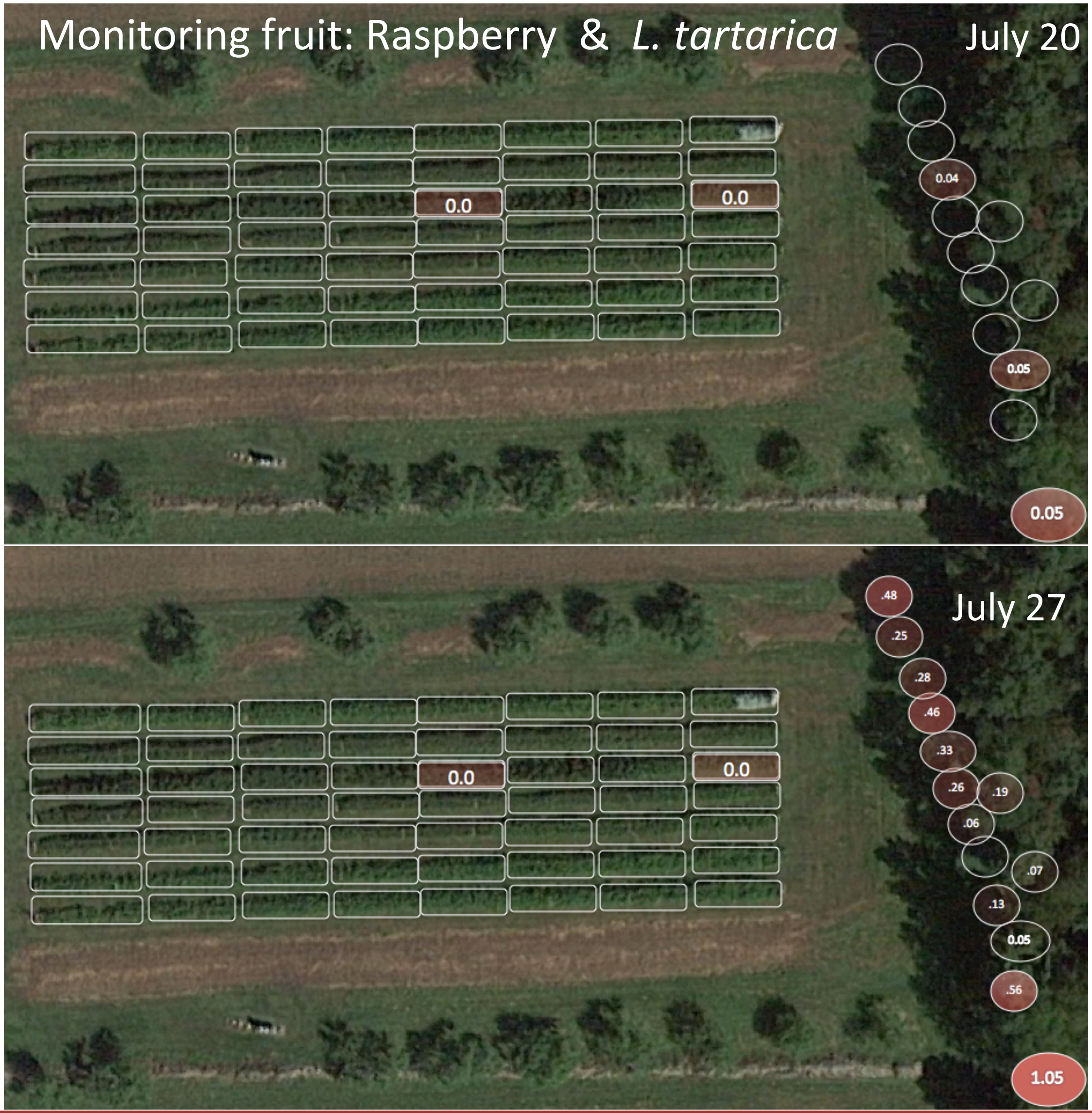
Honeysuckle is a primary host for SWD; *L. tartarica* fruit favored over raspberry in June-August.

Would management of SWD in a favored landscape hosts reduce risk in agricultural crops ?

I. Determine the influence of SWD development in non-crop host to crop infestation levels.

II. Evaluate non-crop plant host fruit to reduce early populations comparing ATK influence to UTC.

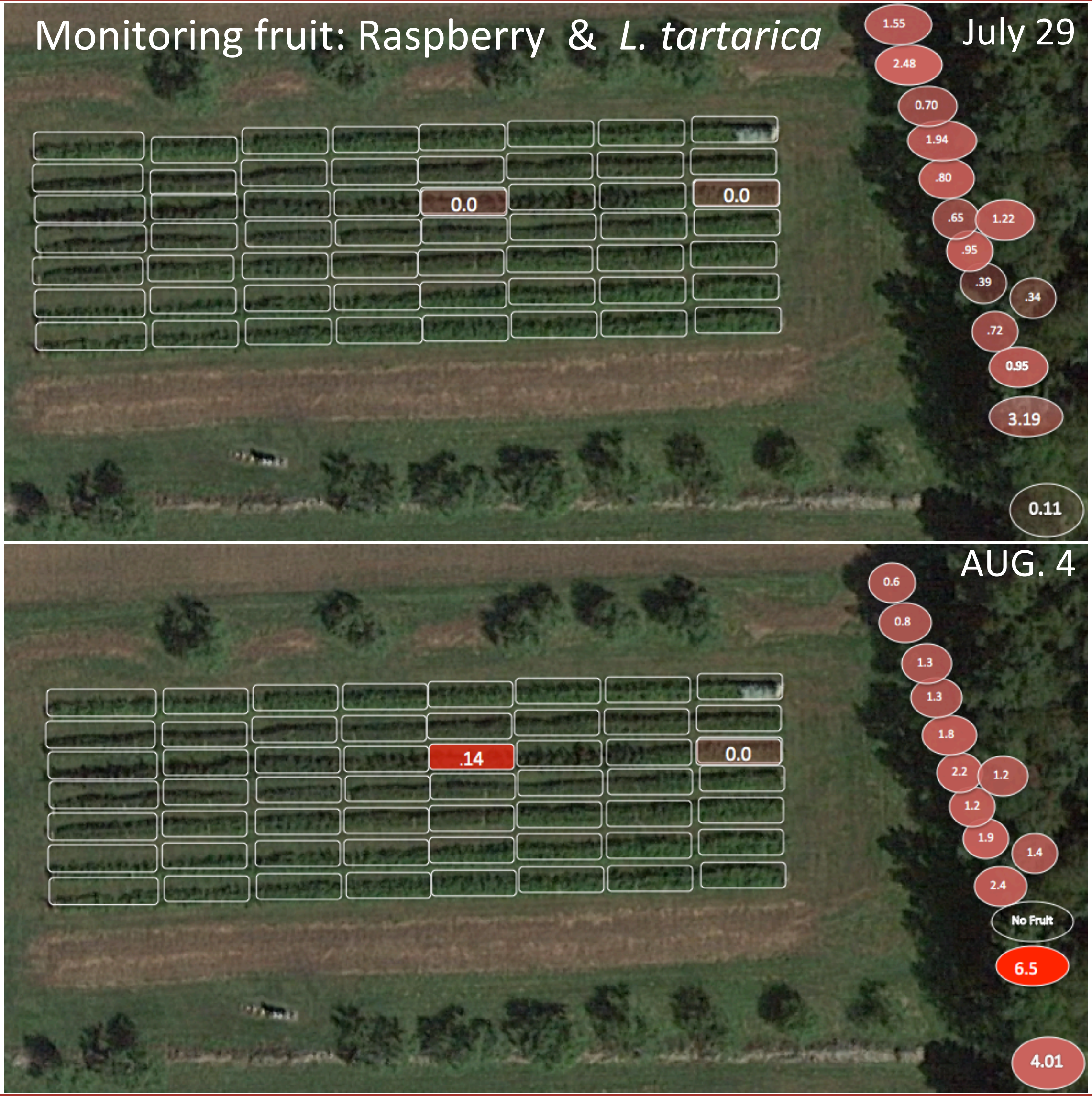
SWD Attract and Kill Management 2015



WestWind Farm, Accord NY

- First SWD eggs found in *L. tartarica* on 20 July
- SWD populations build over several weeks prior to migration to commercial fruit.

SWD Attract and Kill Management 2015

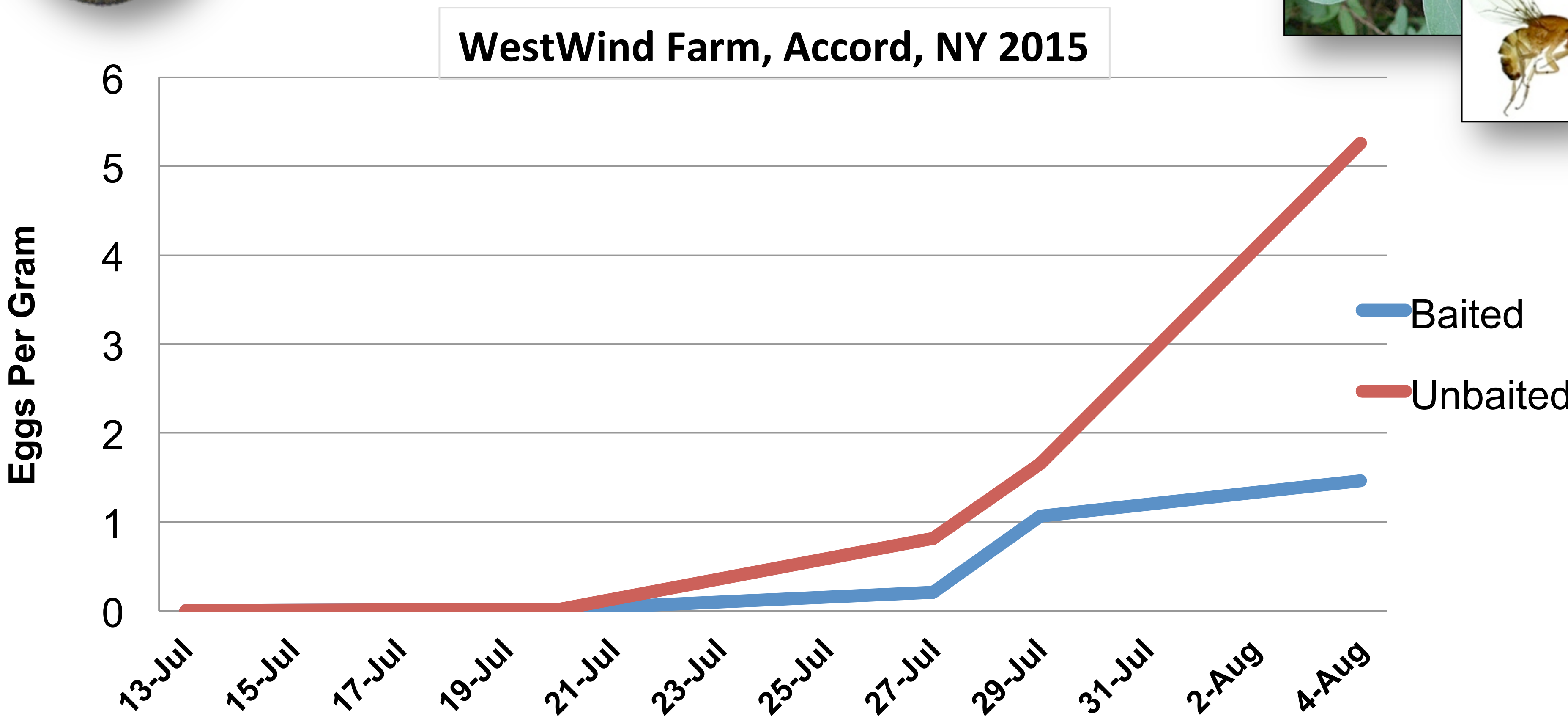


WestWind Farm

- First SWD eggs found in raspberry on 4 August.
- Raspberry collections taken through to the end of season.

Assessment of ATK Stations in *L. tatarica*

Goal: To reduce SWD populations prior to migration into raspberry fields

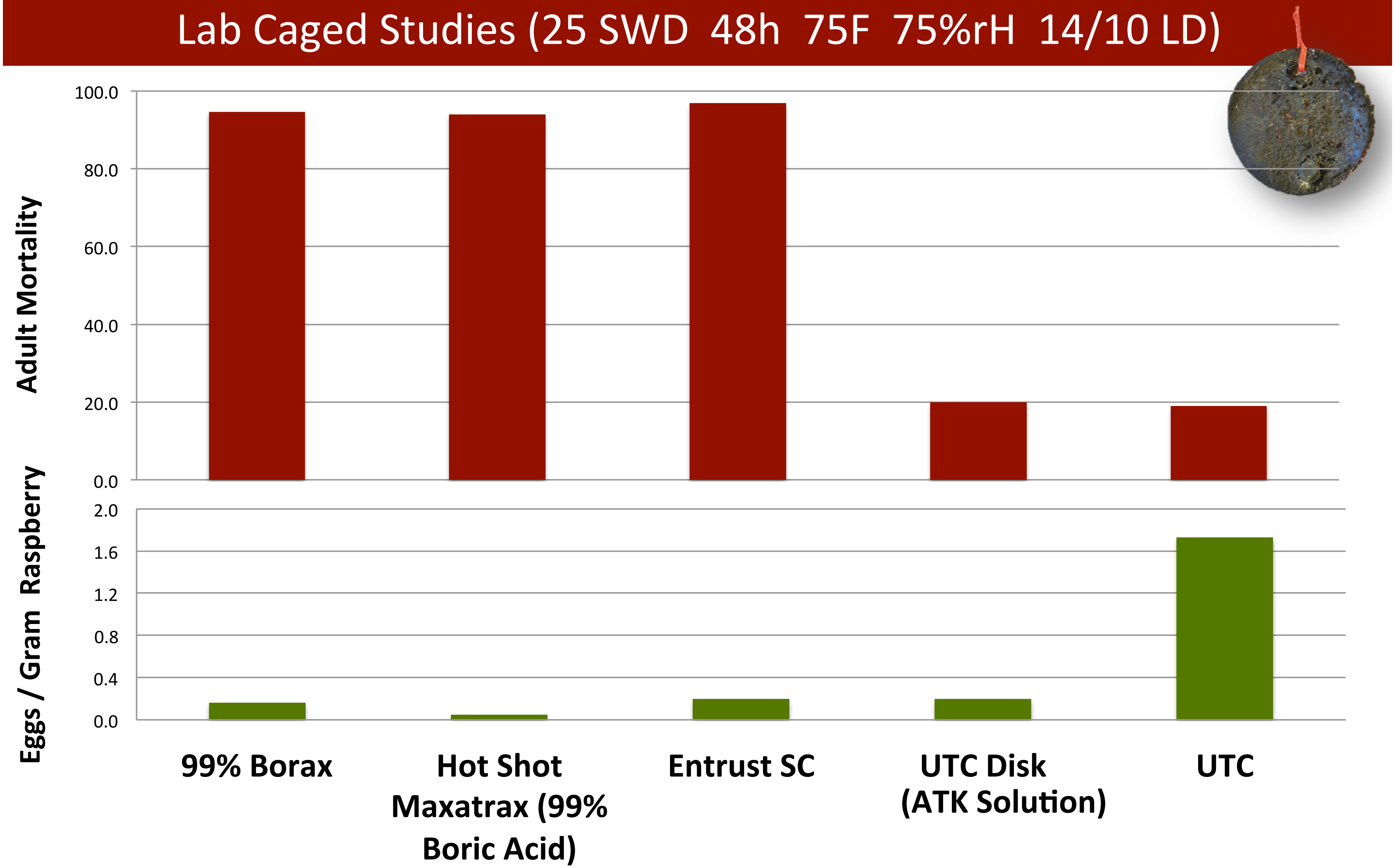


Methods: Development of Attract and Kill for Management of SWD in Small Fruit

Insecticide Product	Active Ingredient (IRAC Group)
Malathion 5EC	malathion (IRAC 1B)
Imidan 70W	phosmet IRAC 1B)
Assail 30SG	acetamiprid (IRAC 4A)
Scorpion 35 SL	dinotefuran (IRAC 4A)
Brigade EC	bifenthrin (IRAC 3A)
Mutang Max	zeta-cypermethrin (IRAC 3A)
Pyganic EC 1.4	pyrethrin (IRAC 3A)
Triple Crown	bifenthrin, imidacloprid, zeta-cypermethrin (IRAC 3A, 4A)
Delegate WG	spinetoram (IRAC 5)
Entrust SC	spinosad (IRAC 5)
Exirel	cyazypyr (IRAC 28)
BotaniGard; Mycotrol	*Beauveria bassiana* strain GHA
BalEnce	*Beauveria bassiana* Diptera-specific strain (HF23
Boric Acid	99% Boric Acid
Hot Shot Maxattrax Roach Powder	99% Boric Acid formulated

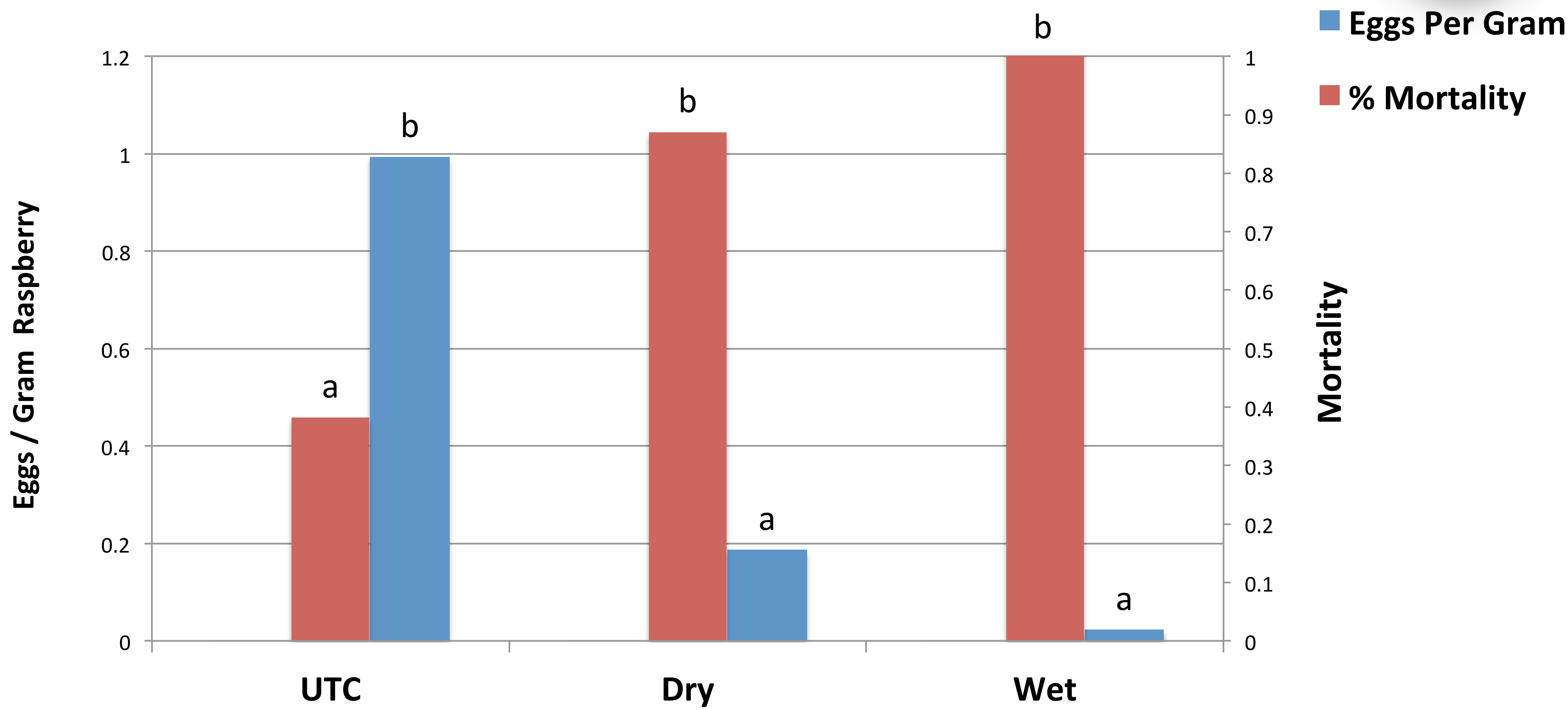
Attract and Kill Station Efficacy

Lab Caged Studies (25 SWD 48h 75F 75%rH 14/10 LD)



Attract and Kill Station Recharge Efficacy

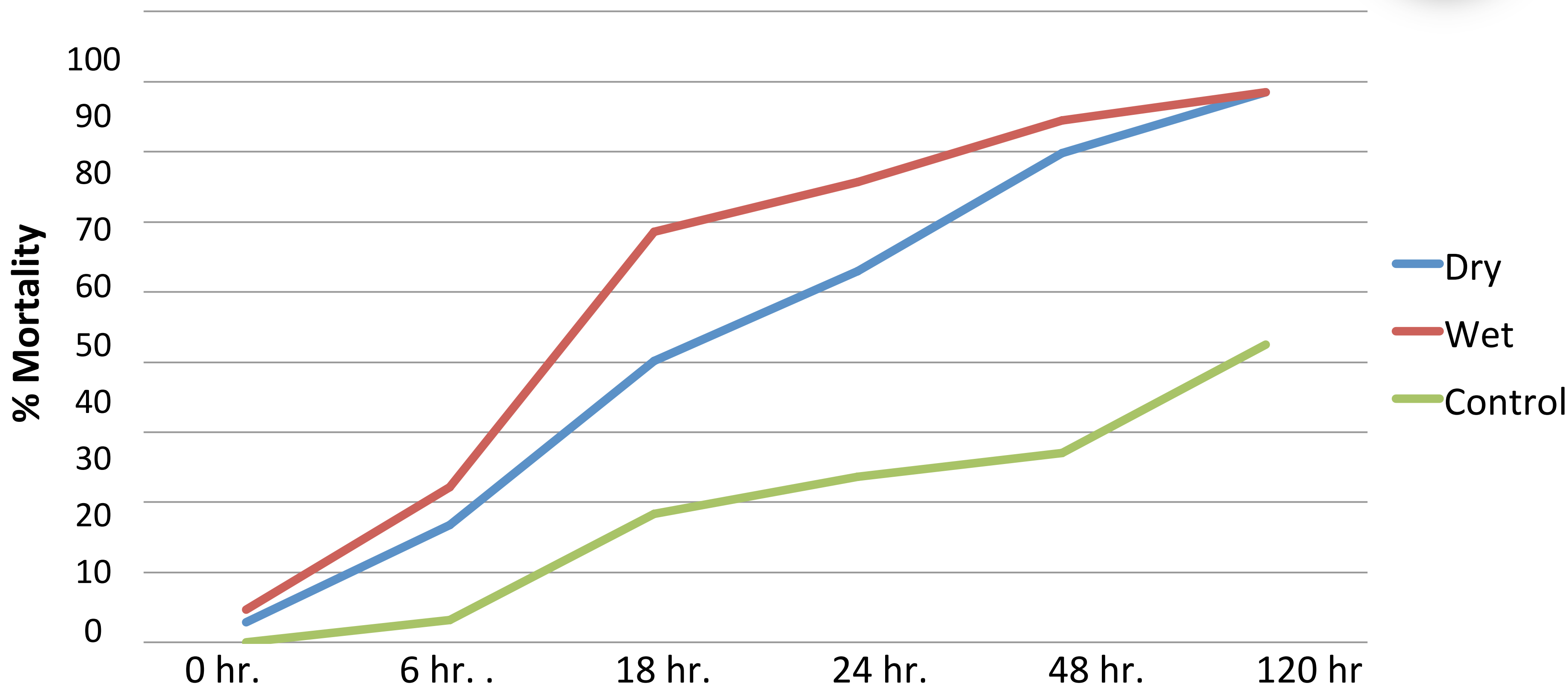
SWD Eggs Per Gram of Raspberry & Adult Mortality @ 72h
24h (Wet) vs 7d (Dry) Borax Treated Disks



1% A.I. Entrust (spinosad-Dow)

Attract and Kill Station Recharge Efficacy

SWD Adult Mortality



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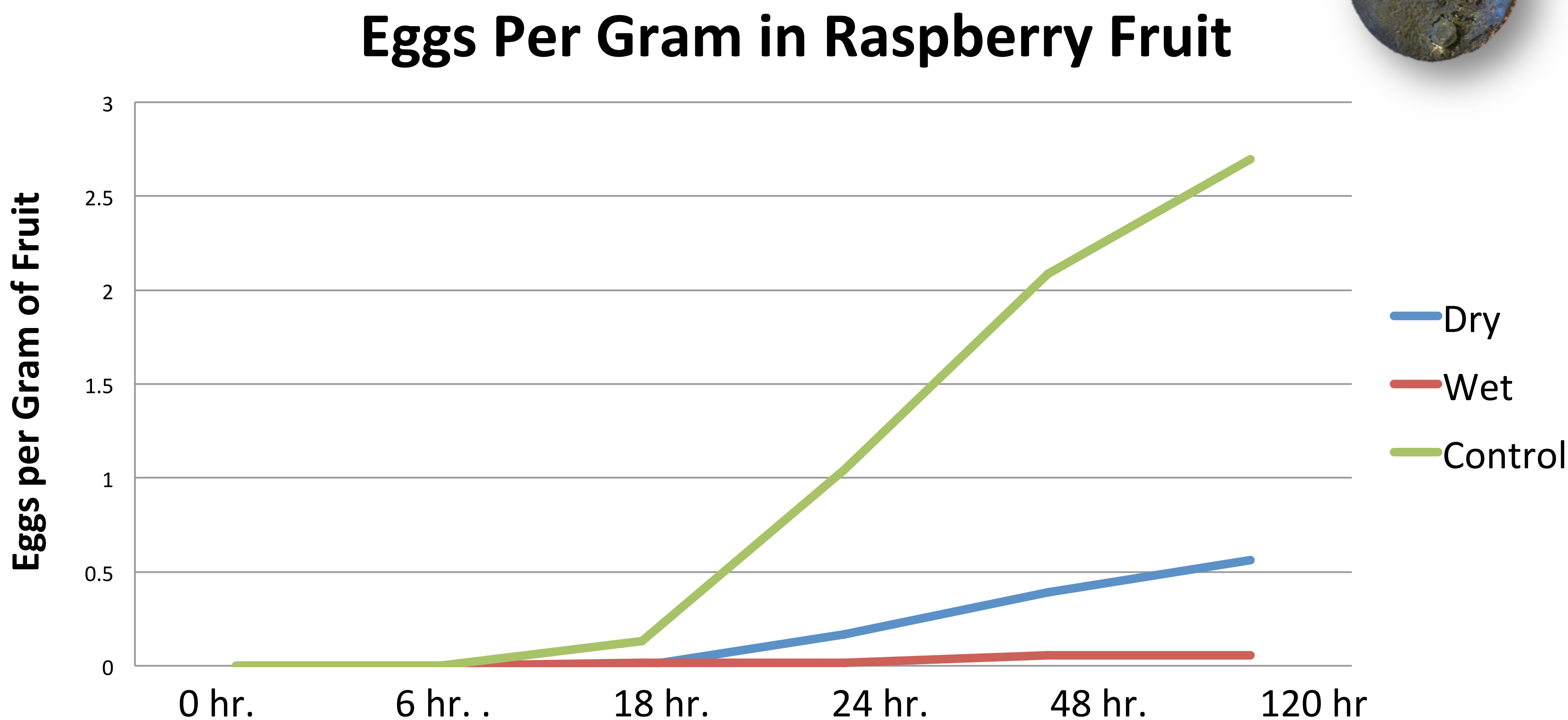
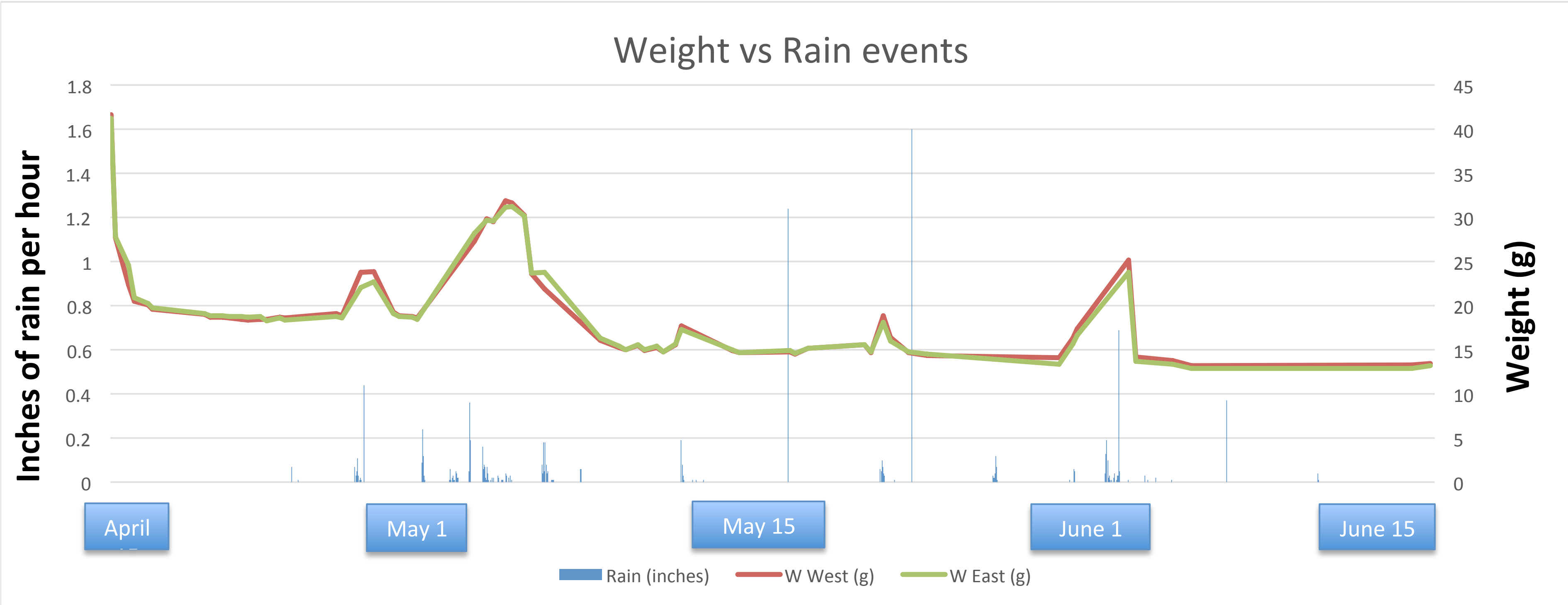
Attract and Kill Station Recharge Efficacy



1% A.I. Entrust (spinosad-Dow)

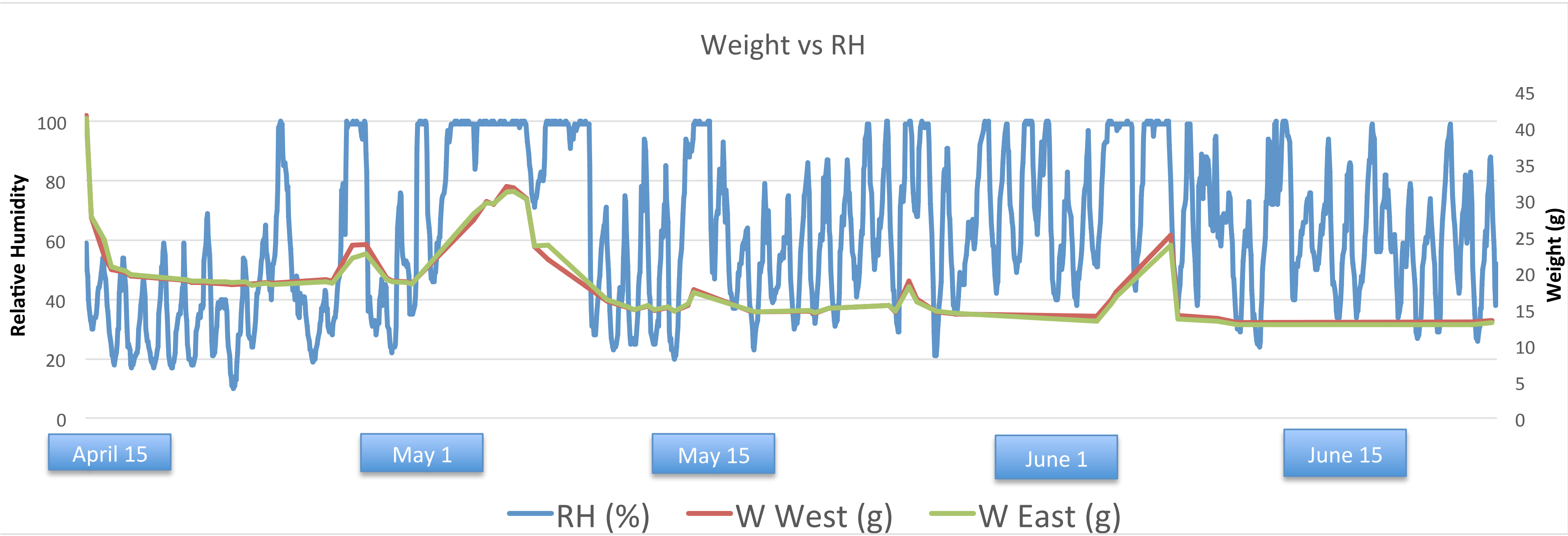
Insecticidal Options for AtK Stations



Observations

- Initial weight loss of ≥50% in 30 hours and overall seasonal weight loss of 70%.
- Extended rain events increase flucations in AtK disk weight.

Attract and Kill Station Recharge Efficacy



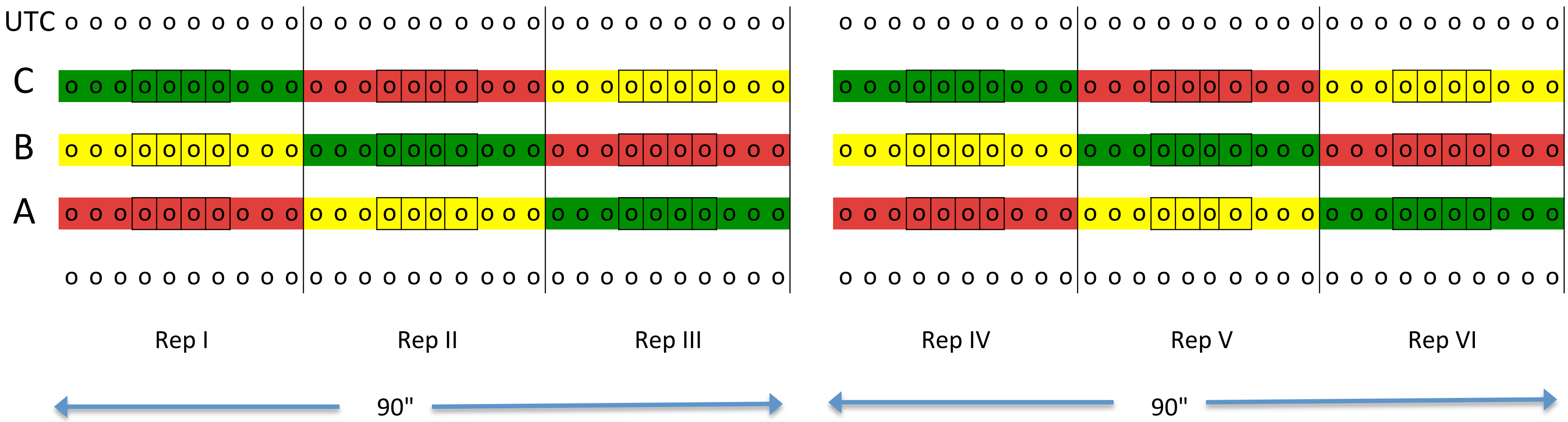
Observations

- Extended high relative humidity also increase weight.
- Inversely, low rH reduces weight.
- Morning dew is also absorbed by the disk.

Attraction of Drosophila to AtK from Morning Dew

June 14th – September 19th 8:30 AM,

Experimental Field Design*



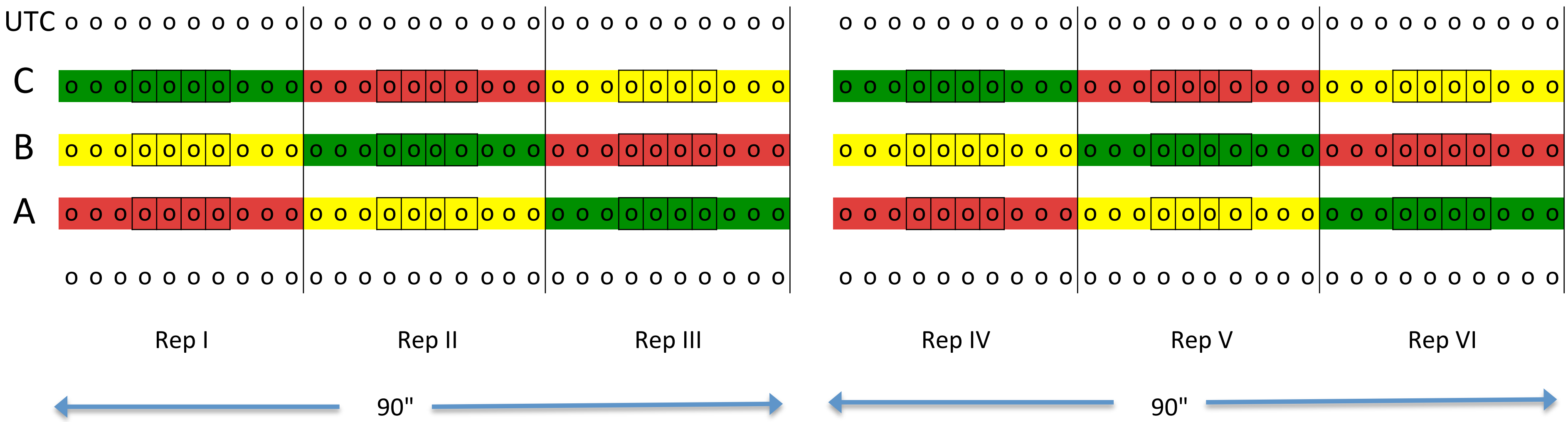
3 Raspberry Plantings on 3 Farm sites in two NY counties
1 Conventional & 2 Organic Production Systems

AtK placement timed for each row (A,B,C)

A. 1st SWD in NY (14th June)
B. 1st SWD on site (19th June)
C. 1st SWD oviposition of fruit (25th June)

* Row spacing- 11'; plant spacing 3'; 2 of 3 sites used wire trellis used to hang AtK stations

Experimental Field Design



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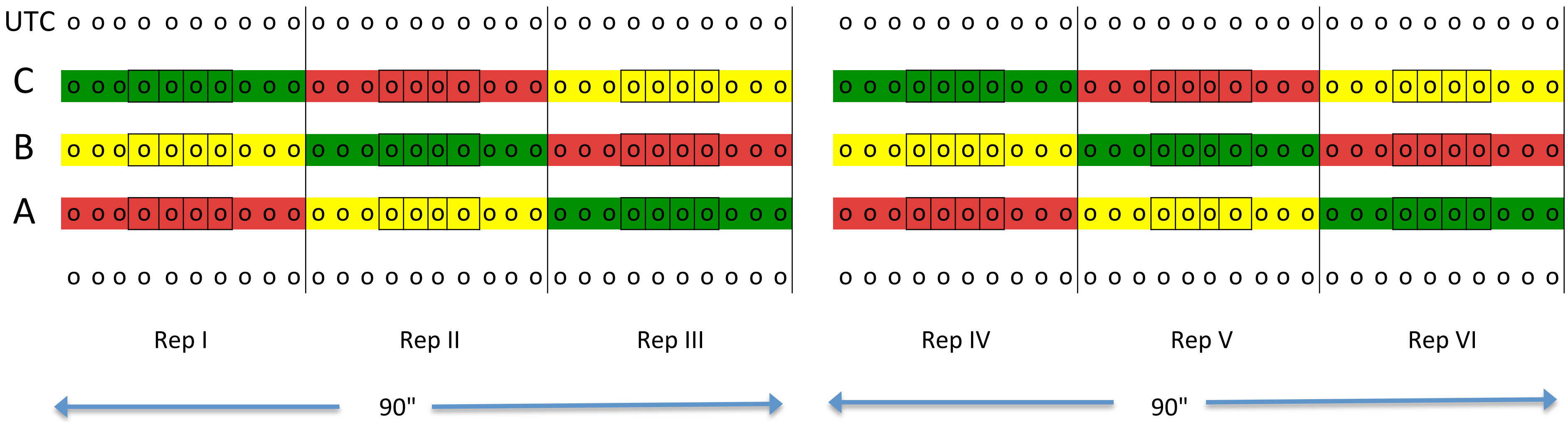
C. 1st SWD oviposition of fruit (25th June)

Split Block

(Reps I-III)
Red and Yellow Disk sprayed weekly

(Reps IV-VI)
Red and Yellow Disk sprayed 2x/week

Experimental Field Design



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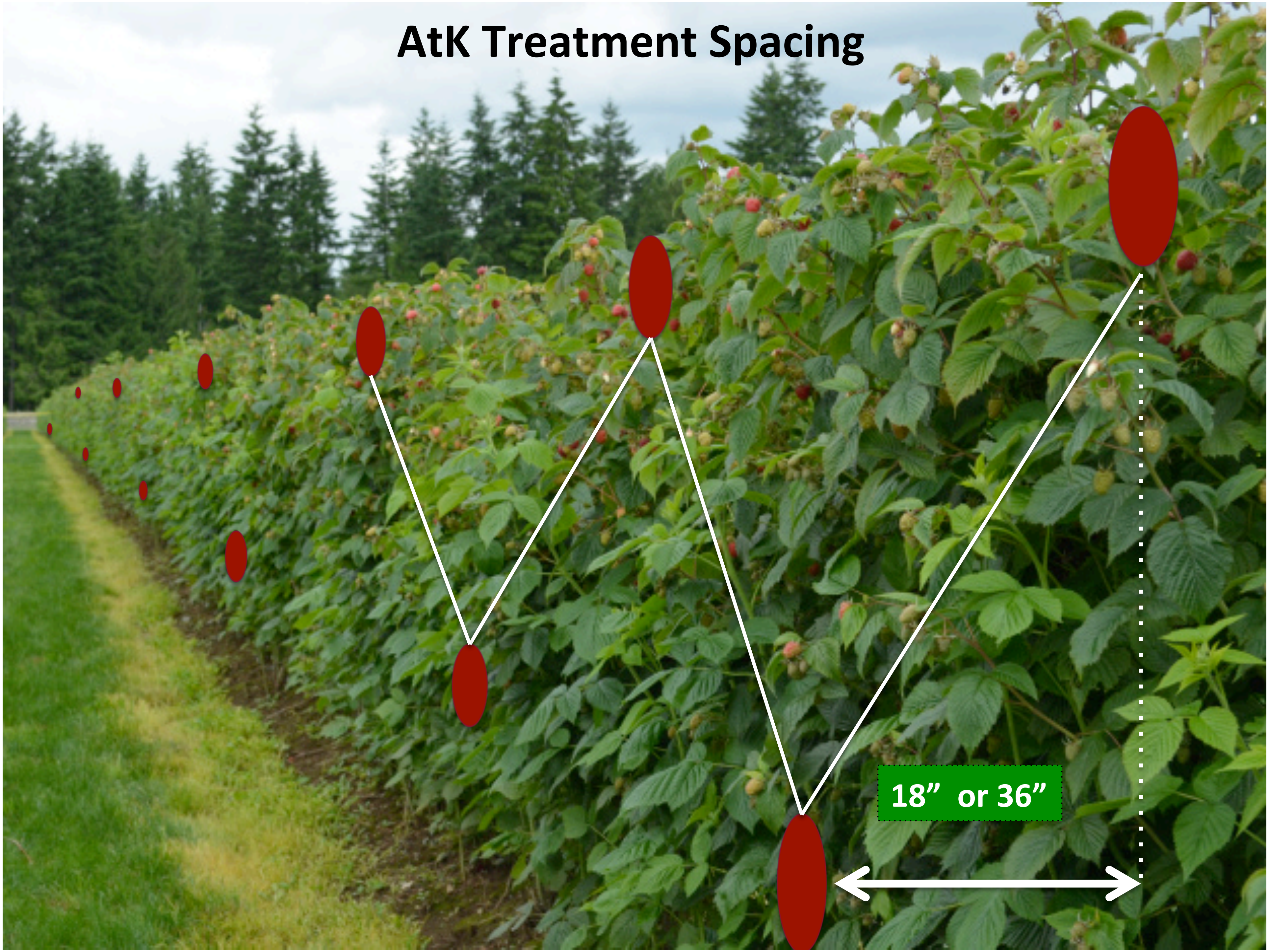
Split Block

(Reps I-III)
Red and Yellow Disk sprayed weekly

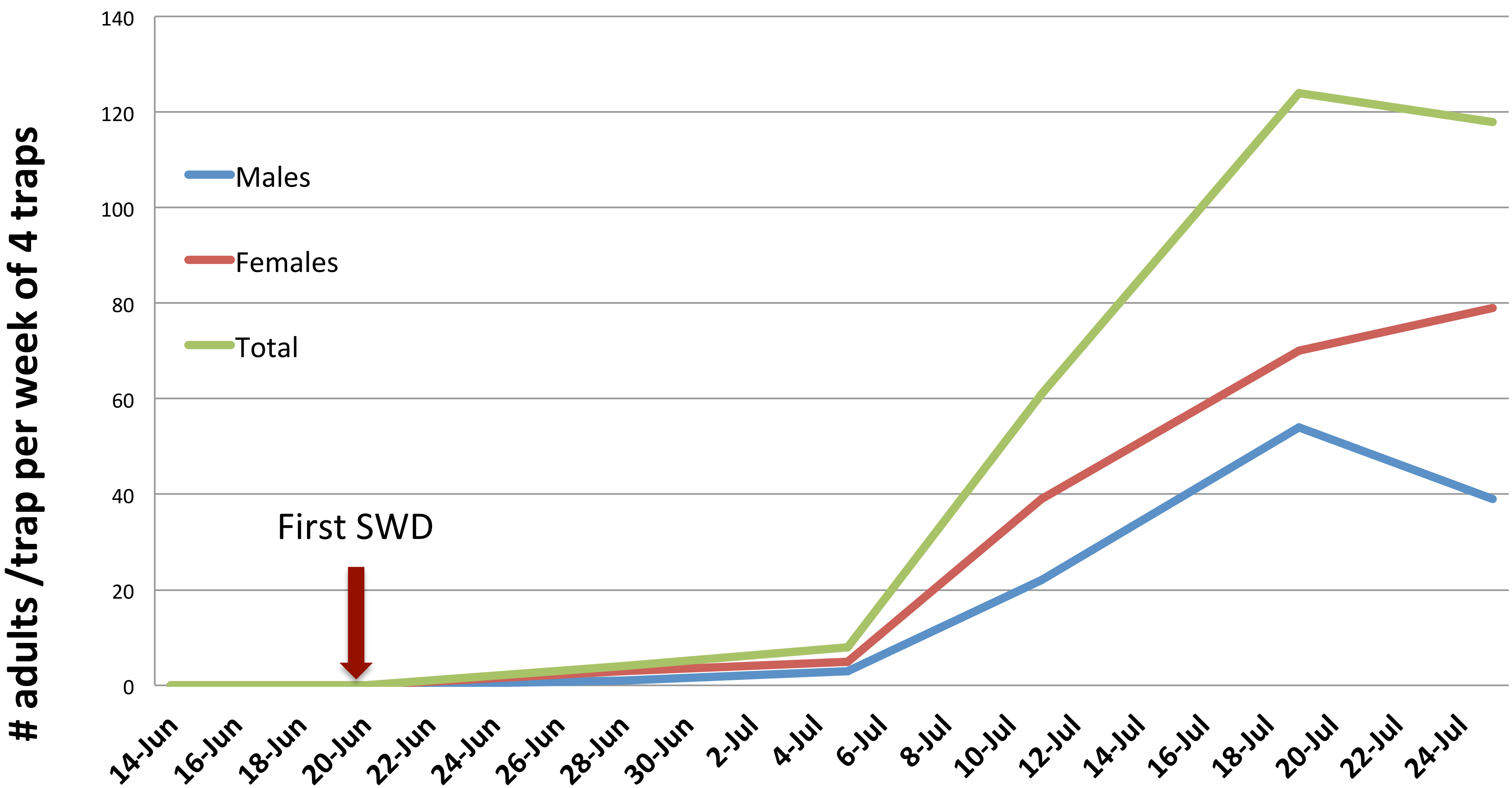
(Reps IV-VI)
Red and Yellow Disk sprayed 2x/week

Treatments

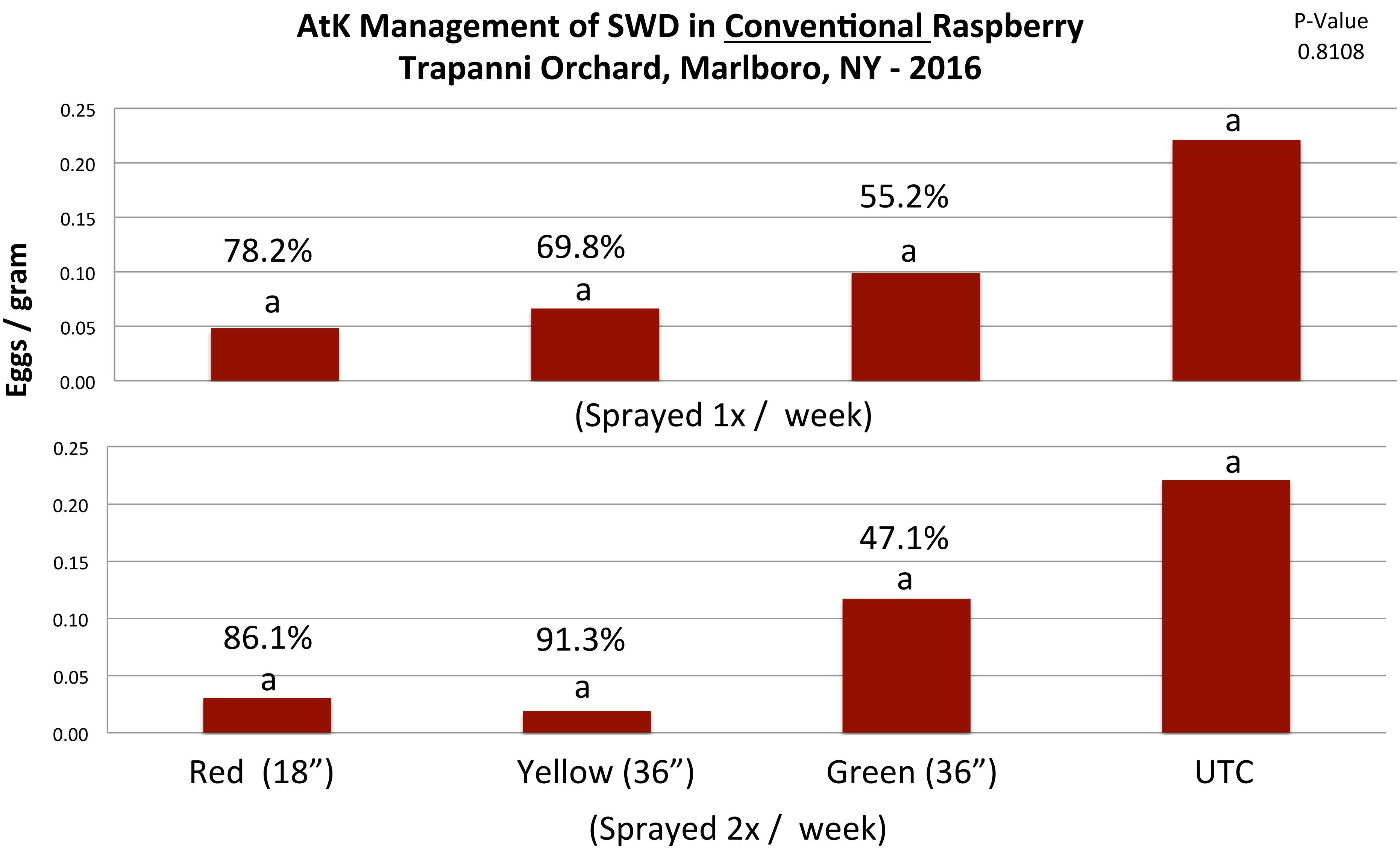
Red	O	1% Borax treated disks spaced at 1.5’ (120) Disks/ side = 240 disks/ row
Yellow	O	1% Borax treated disks spaced at 3’ (60) Disks/ side = 120 disks/ row
Green	O	UT disks / no recharge spaced at 3’ (60) Disks/ side = 120 disks/ row


AtK Treatment Spacing
18” or 36”

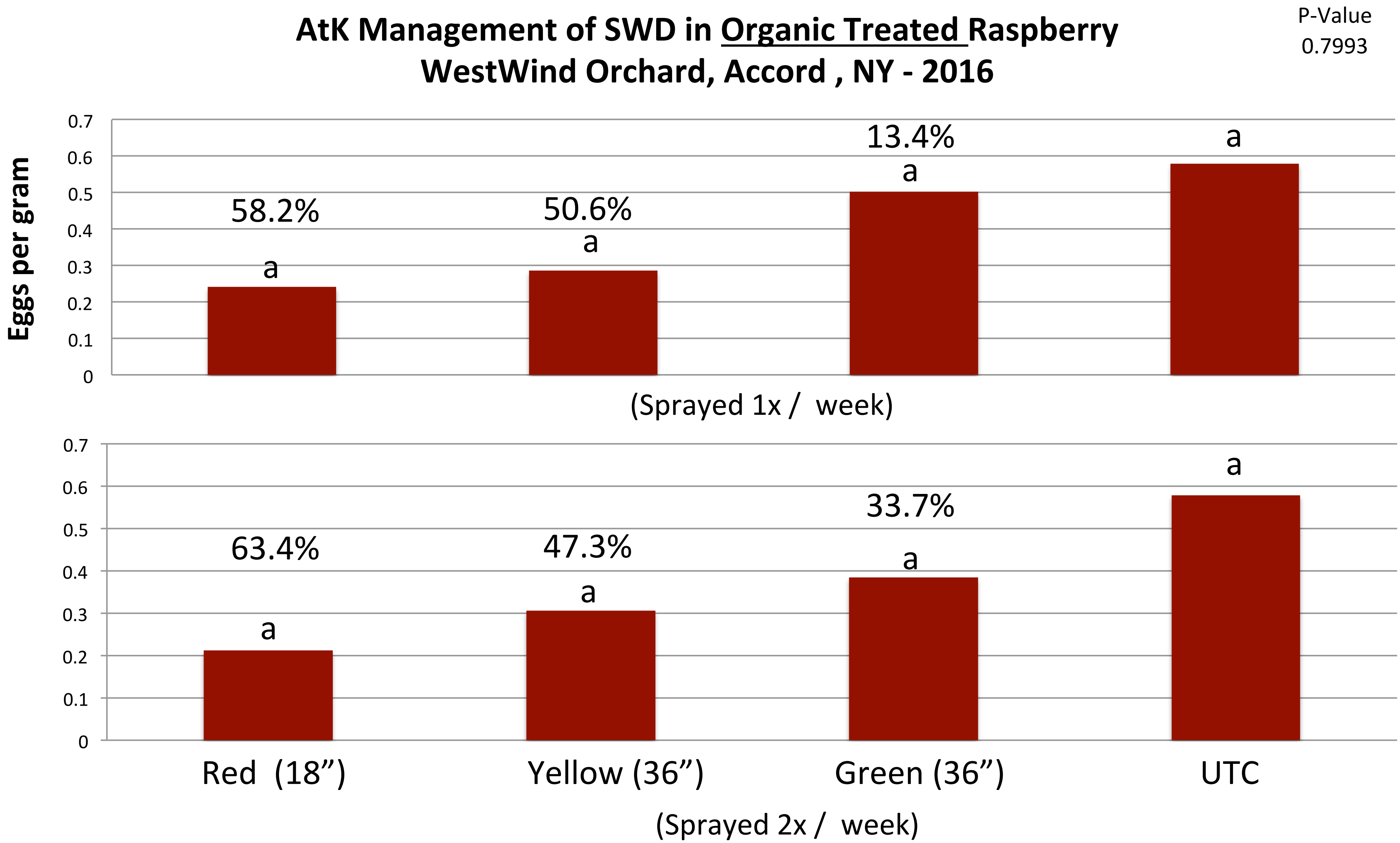
SWD in Conventional Red Raspberry Planting
Milton, NY - 2016



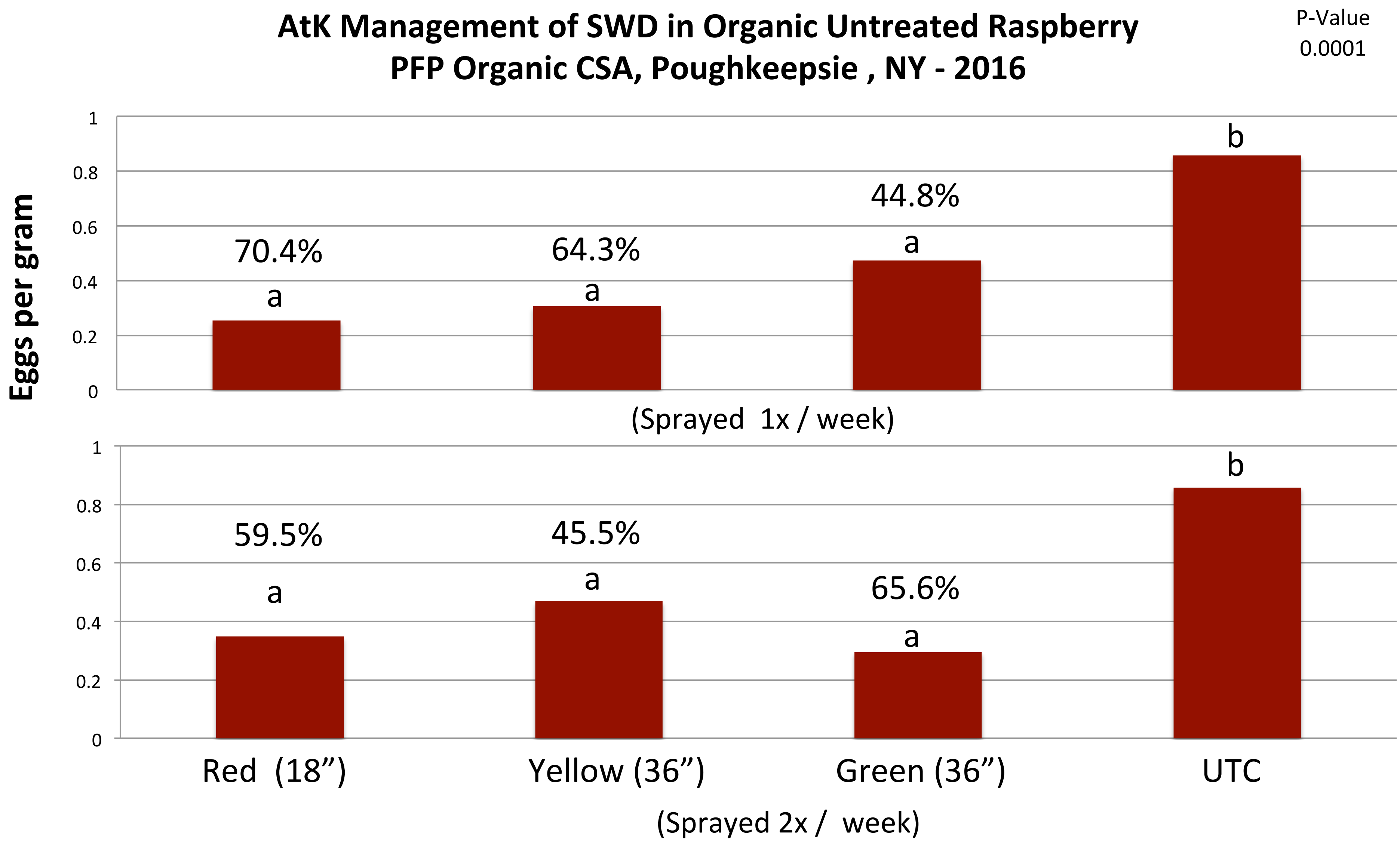
SWD Damage Means in Raspberry Fruit



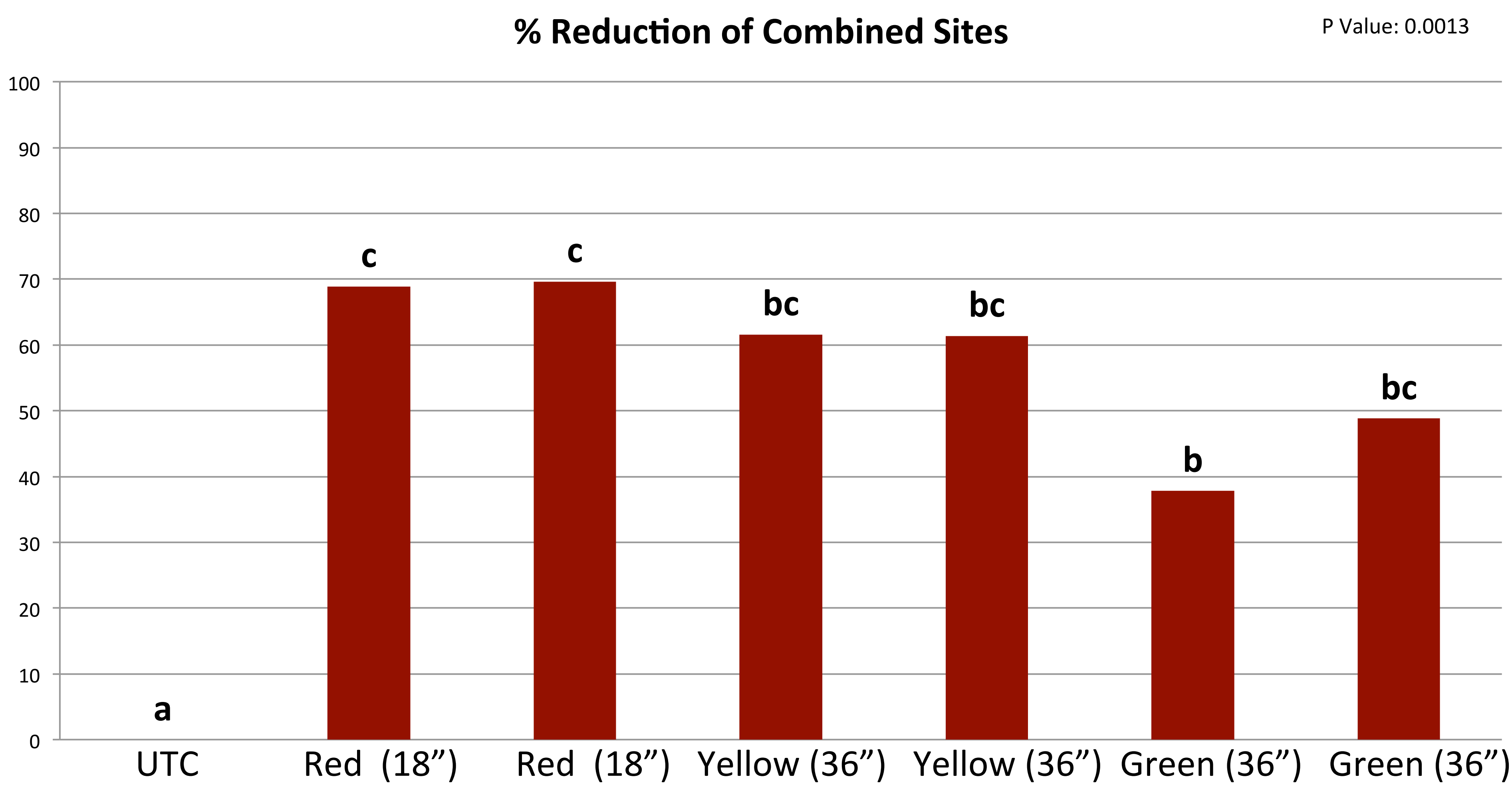
SWD Damage Means in Raspberry Fruit



SWD Damage Means in Raspberry Fruit



Combined Farm & AtK Application Timing



Sprays/wk. 1x/wk. 2x/wk. 1x/wk. 2x/wk. ----No Recharge-----

Table 1. Evaluations Of Attract and Kill stations For Controlling Spotted Wing Drosophila in Raspberry [a]. Hudson Valley Research Lab. Highland N.Y. - 2016

Treatment /		% Reduction in Oviposition at each Site			
Spacing	Timing	WW	PFP	Trapani	All Sites
Boric Acid 18" (Red)	1x Weekly	58.2 a	70.4 a	78.2 a	68.9 c
Boric Acid 36" (Yellow)	1x Weekly	50.6 a	64.3 a	69.8 a	61.6 bc
Means		54.4	67.4	74.0	65.3
Boric Acid 18" (Red)	2x Weekly	63.4 a	59.5 a	86.1 a	69.7 c
Boric Acid 36" (Yellow)	2x Weekly	47.3 a	45.5 a	91.3 a	61.4 bc
Means		55.4	52.5	88.7	65.6
Untreated Disk 36" (Green)		13.4 a	44.8 a	55.2 a	37.8 b
Untreated Control		0.0 a	0.0 b	0.0 a	0.0 a
P value for transformed data		0.7993	0.0001	0.8108	0.0013

[a] Evaluation made on Raspberry June to September. Data were transformed using $\log_{10}(x+1)$ using Fishers Protected LSD ($P \leq 0.05$). Treatment means followed by the same letter are not significantly different. Arithmetic means reported.

Conclusion

- Attract and kill strategies have been shown to provide reduced levels of infestation from spotted wing drosophila in conventional and organic raspberry production systems.

- Further study of placement density and reapplication intervals of AtK disks for optimumal control is needed prior to recommendations for use.

- Use of AtK + 1% Boric Acid in combination with cultural control, frequent harvest intervals, berry sanitation and harvest low temperature storage strategies may decrease the impact of SWD while reducing the resistance potential in SWD populations from frequent insecticide use.

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Questions??

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