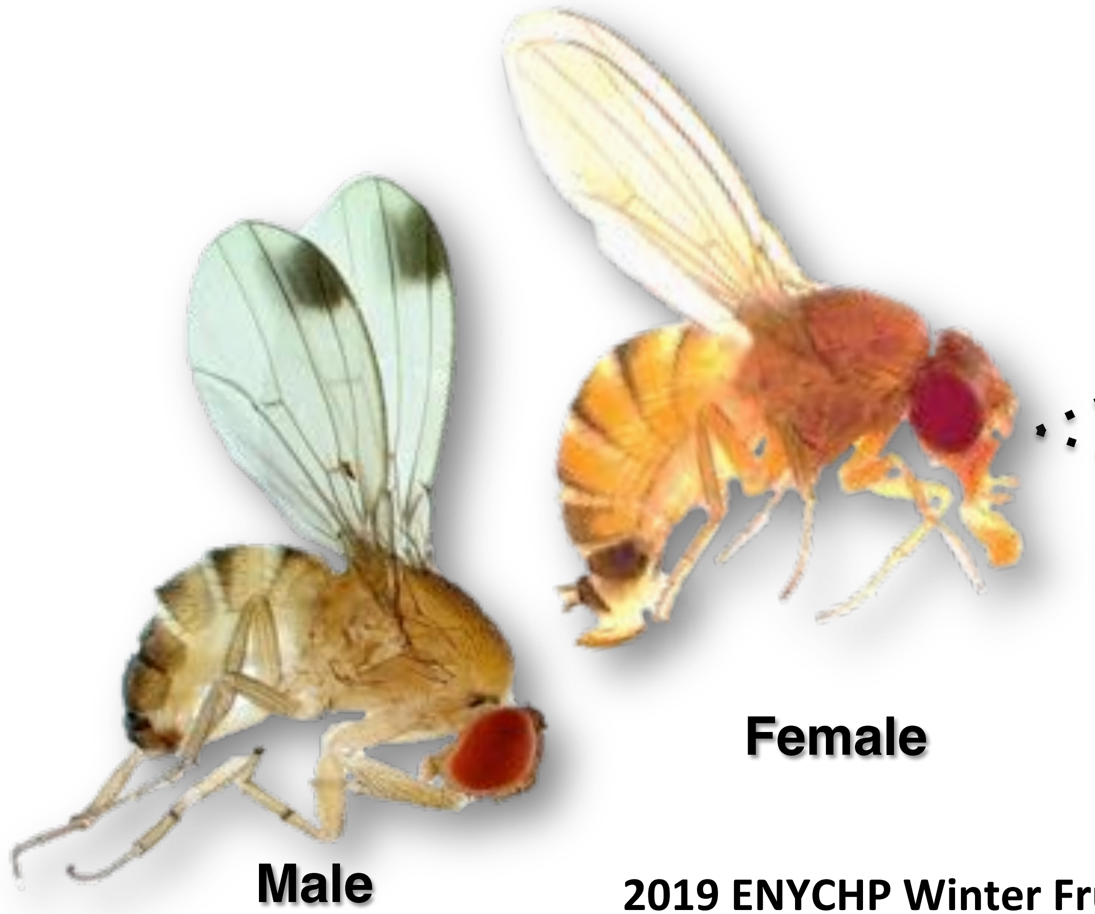
Developing Exclusion and Attract-and-kill Strategies To Manage Spotted Wing Drosophila In Raspberry PYO Production.



2019 ENYCHP Winter Fruit Schools
Desmond Hotel & Conf Ctr, Albany , NY

Cornell University
Hudson Valley Research Laboratory

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

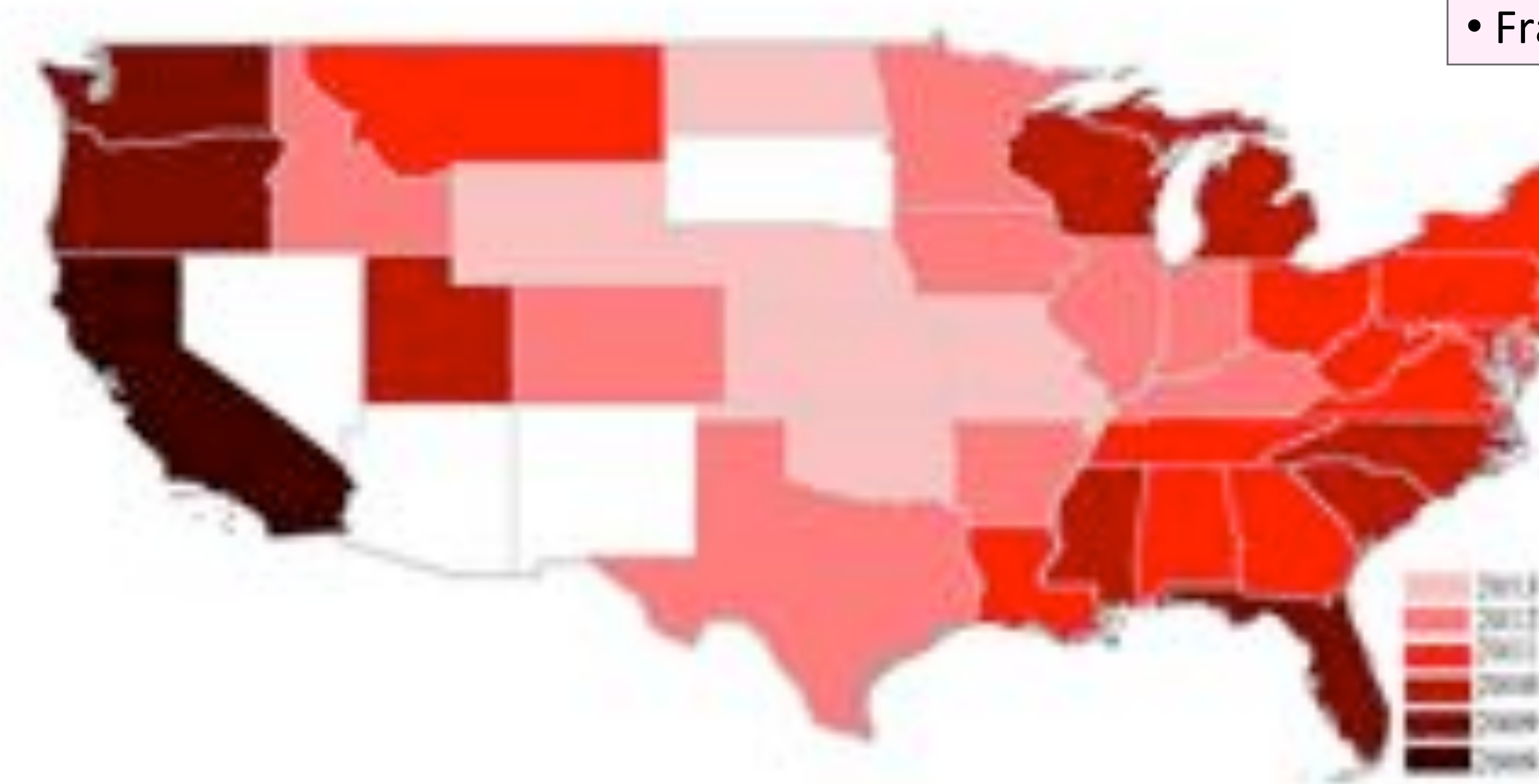
Leading edge of wing has dark spot

Unbroken abdominal bands

SWD Spread from 2008 – 2013 in the US

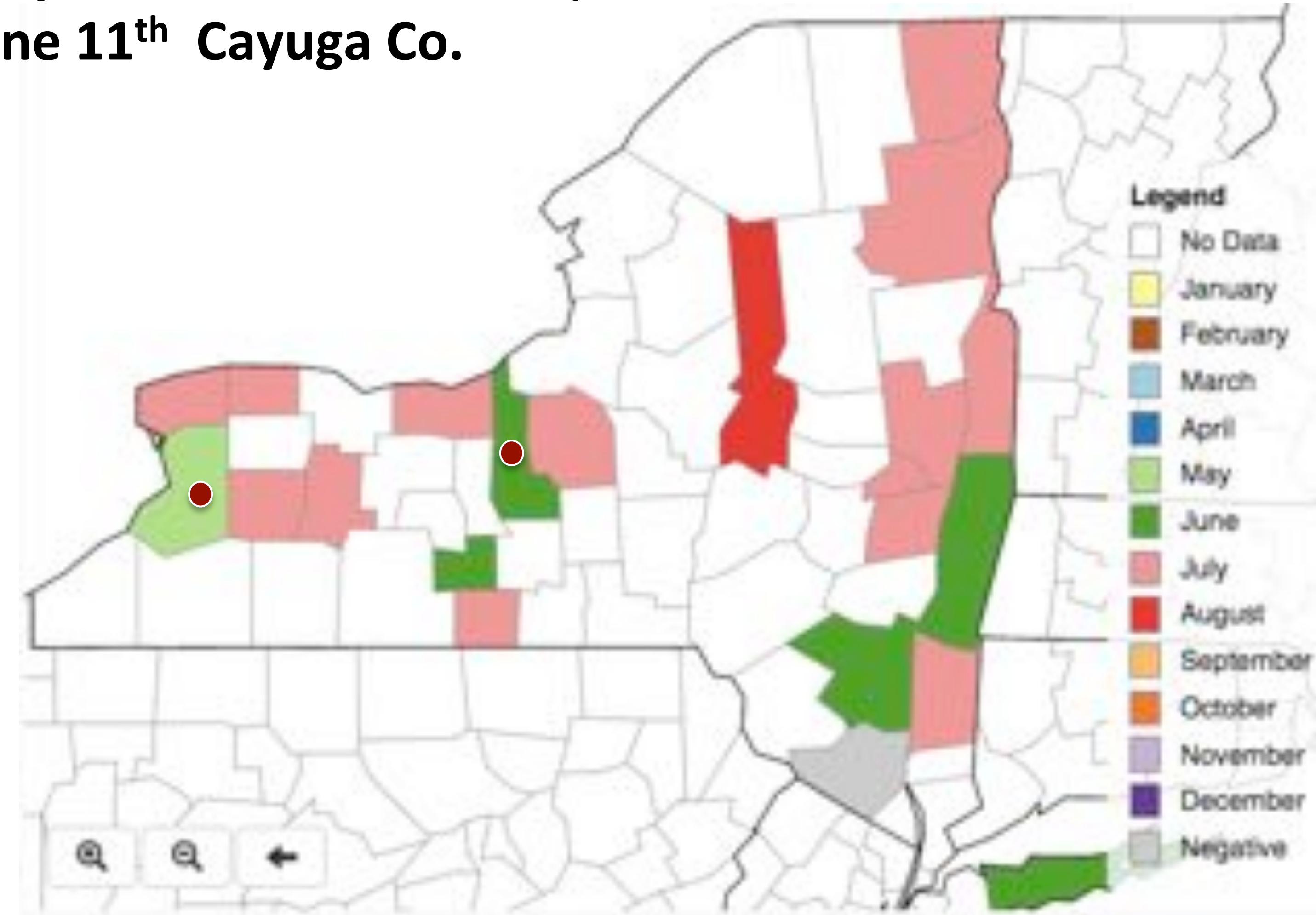
Hawaii 1980

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



SWD in New England - 2018

May 31st Orleans Co. NY (first detection: earliest on record)
June 11th Cayuga Co.



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)**	
2018 – May 22nd	**(Erie)**	**2018 – May 19**

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

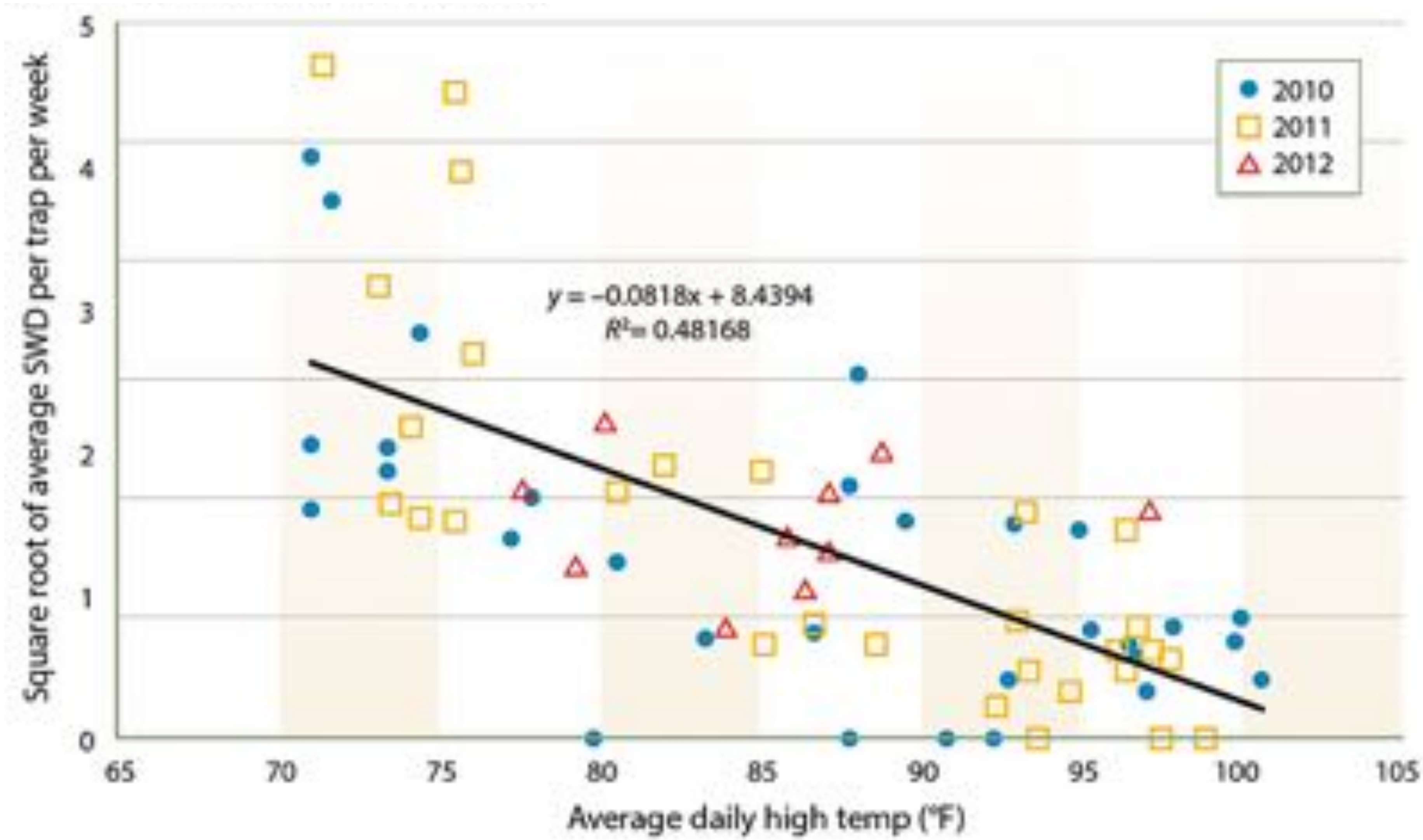
	egg	larvae	pupae	adult	egg to adult
Spring	72 hrs	7 days	15 days	30 days	25.0 days
Summer	12 hrs	5 days	4 days	20-30 days	9.5 days

OW / 1G | 2G | 3G | 4G | 5G | 6G | 7G | 8G

June | July | August | September | October | Nov.

Generational Intervals

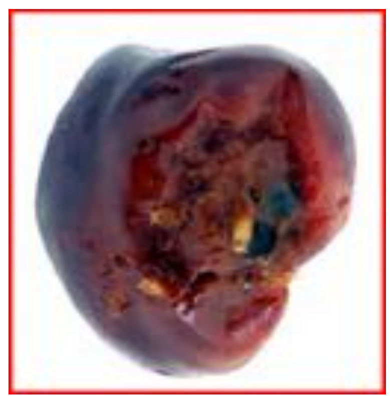
Life Cycle of the Spotted Wing Drosophila
Drosophila suzukii (Matsumurai)



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

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



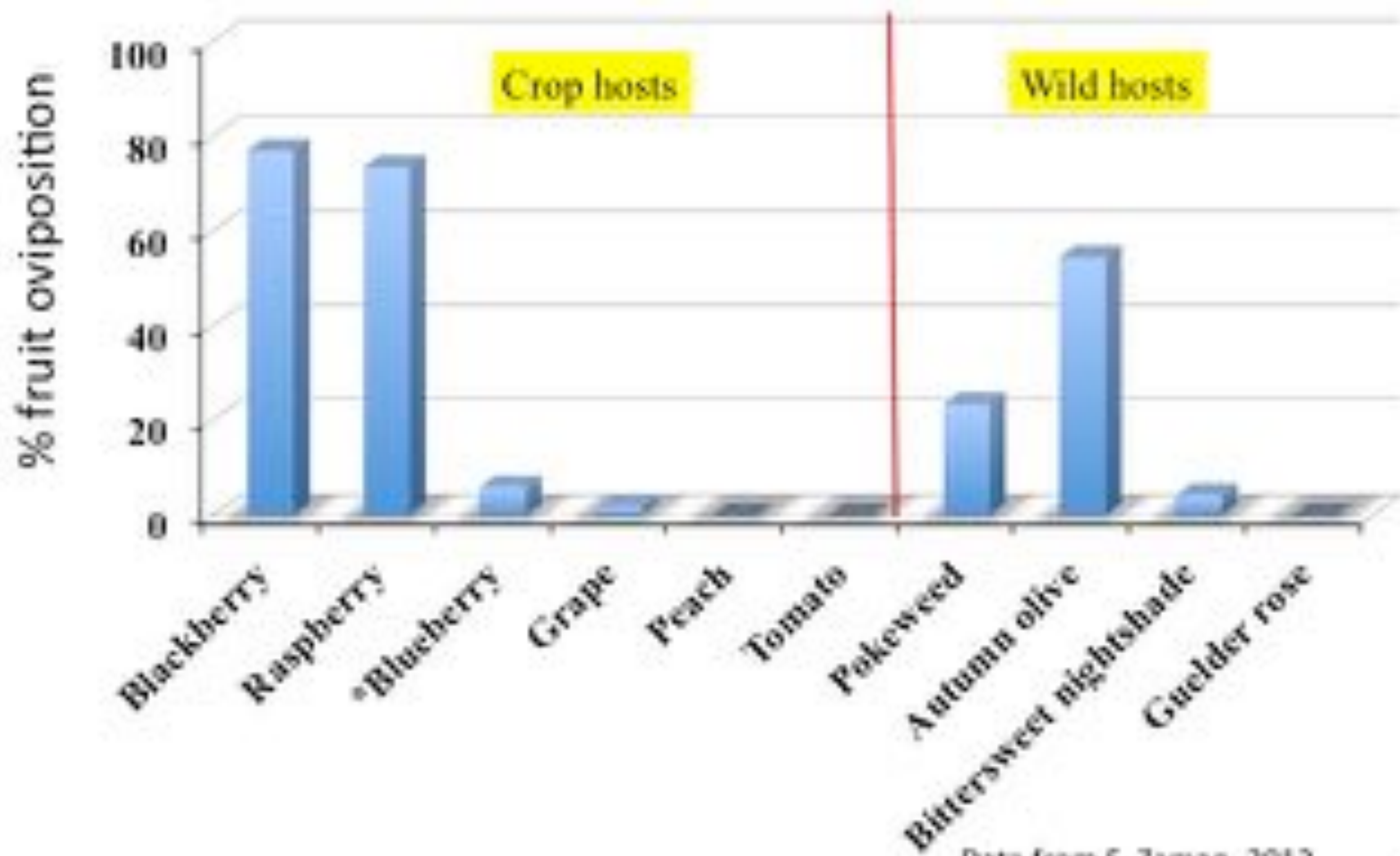
SWD Attract and Kill Management 2015

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.

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



Data from F. Zaman, 2012

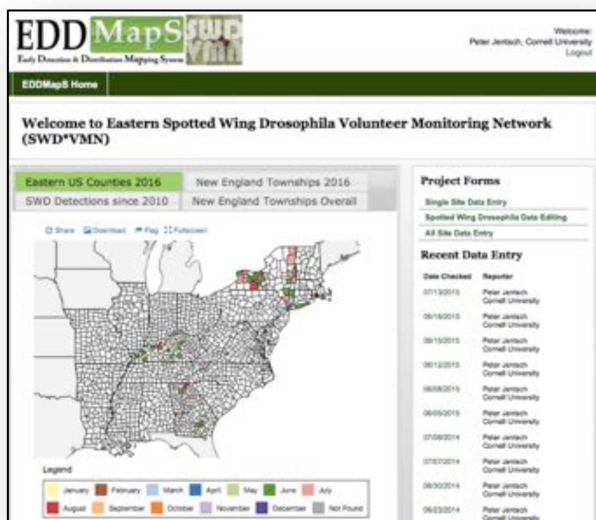
Sampling and Monitoring Protocols

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

Application: Begin at 1st observation of egg laying.



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

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

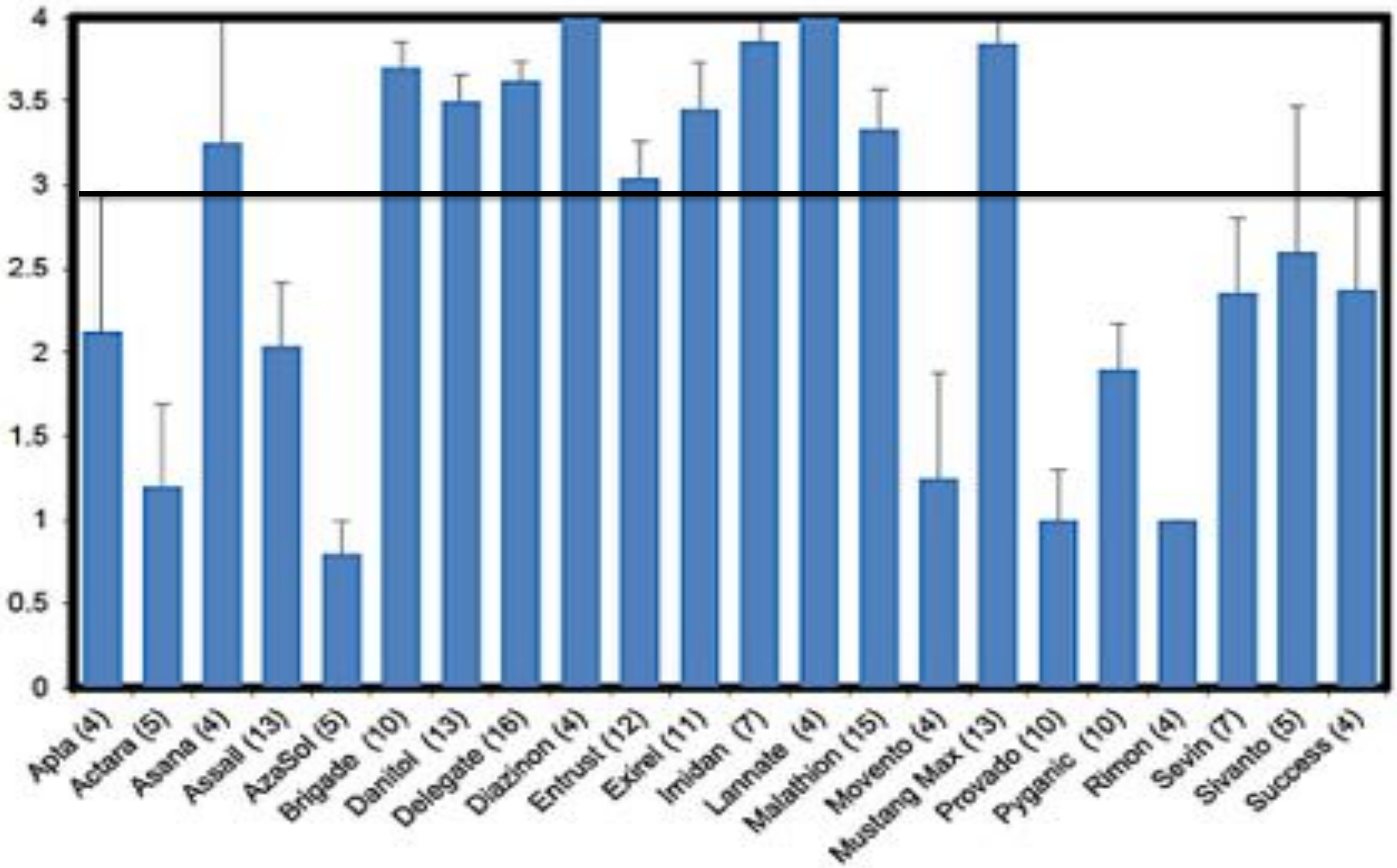


Figure 1. Average ± S.E. efficacy rankings for 22 insecticides that have been tested against SWD in various fruit crops. Insecticides were ranked as not effective (score = 0), weakly active (1), fair (2), good (3), or excellent (4). Only insecticides that had 4 or more submitted are included in the figure,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

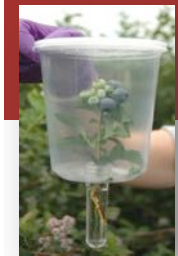
- **Successful control of SWD:** Applications began about three weeks before predicted harvest, keeping tight intervals (six to eight days) using excellent rated insecticides. Consideration for re-application of insecticide shortly after rain events.

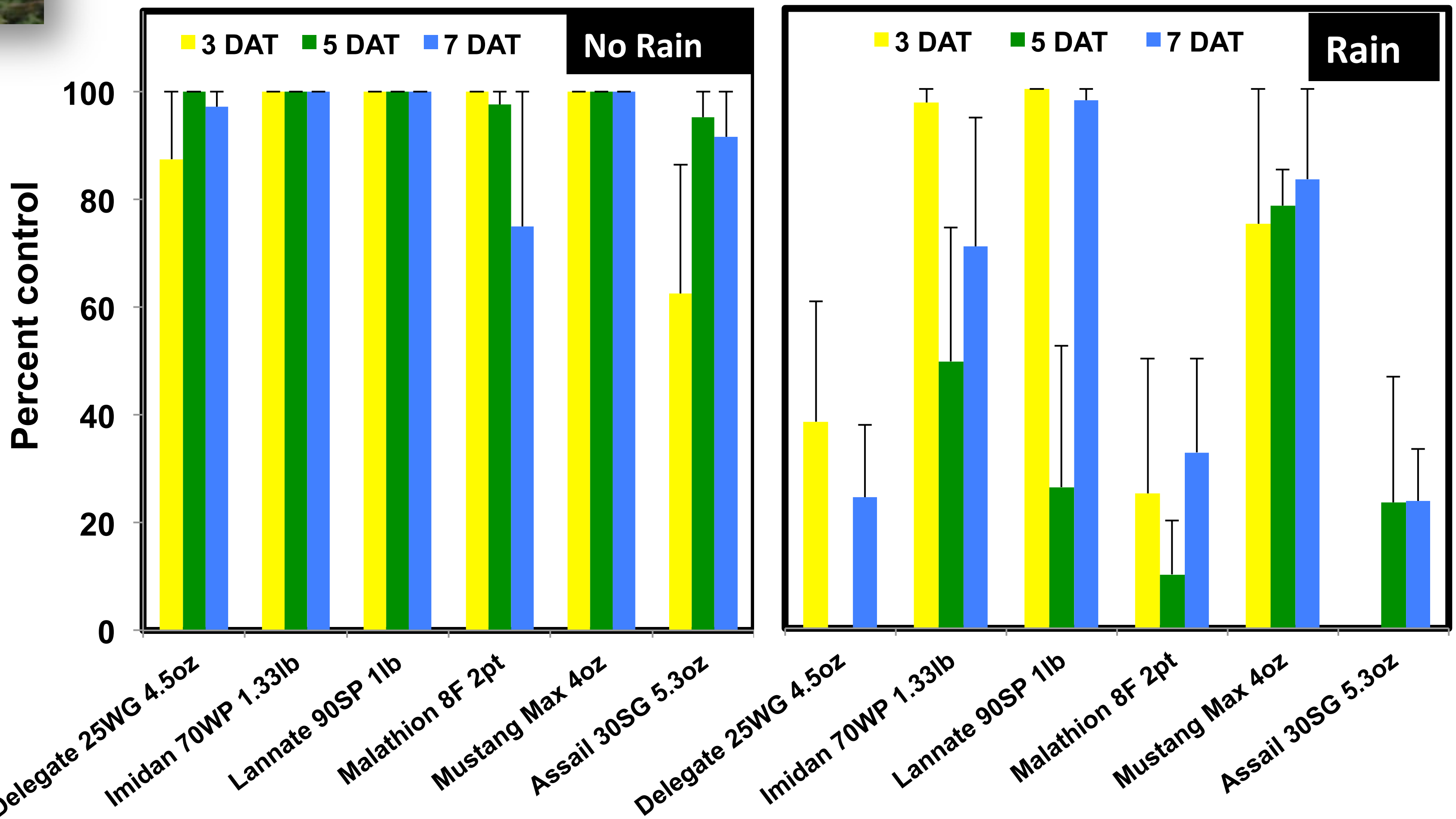
- **Failure: Growers beginning 'early',** four weeks from harvest and trying to stretch the same number of sprays further to keep costs down, suffered SWD larval contamination.

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

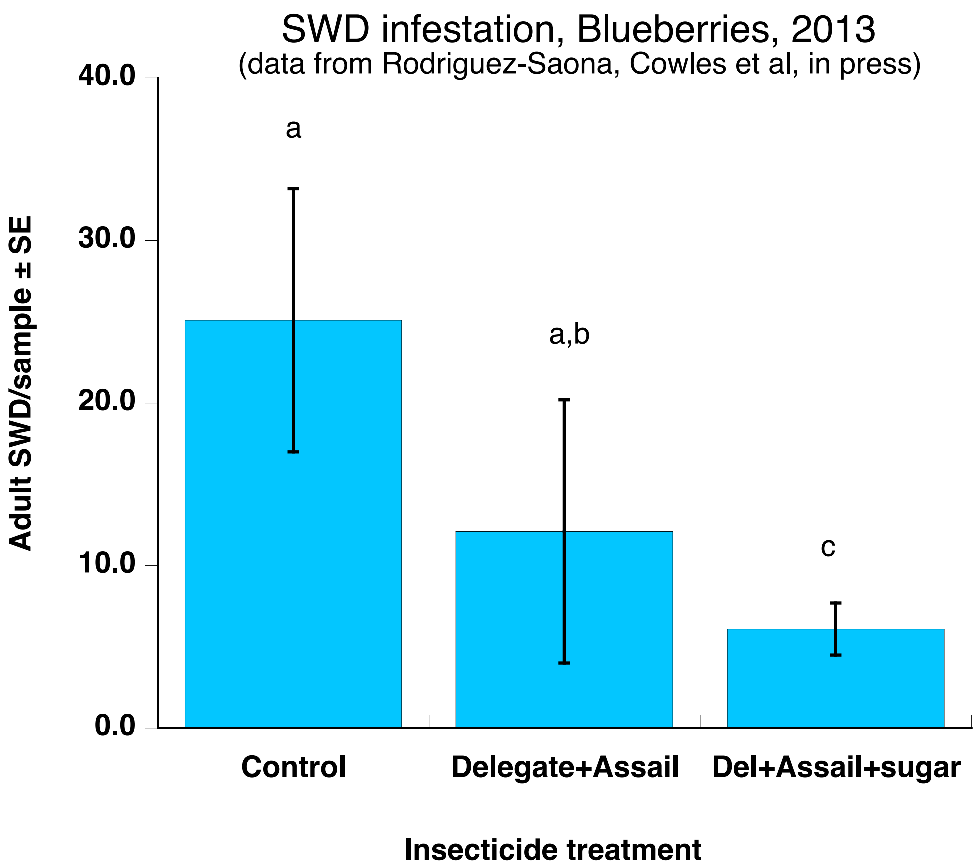




0.8 inches of rain on treated bushes
1 day after application

MICHIGAN STATE UNIVERSITY

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

SUMMARY

- Presently insecticides are 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

Developing AtK Based Literature Eastern US

Tracy Leskey (USDA-ARS)
Developing a Behaviorally Based Attract and Kill System for SWD

- **Color important**; black and red routinely outperformed other colors.
- **A spherical shape: size greater than 2.5 cm acceptable.**
- **Baits** enhance SWD capture
- **SWD infestation in raspberries reduced by 50% when sphere with sugar and bait in caged studies. Sprayed fruit + AtK in combination most effective in managing SWD compared to either alone under high pressure.**

Cesar Rodriguez-Saona, Rutgers State U. Of N.J., Richard Cowles Univ. Conn.
Bait comparisons of SWD in blueberry

- **Suzukii and Trece baits very effective at capturing SWD with Trece and apple cider vinegar capturing higher numbers of non-SWD flies.**

Cowles, R. S., C. Rodriguez-Saona, R. Holdcraft, G. M. Loeb, J. E. Elsensohn, and S. P. Hesler. 2015. **Sucrose improves insecticide activity** against *Drosophila suzukii* (Diptera: Drosophilidae). J. Econ. Entomol. 1 – 14. DOI: 10.1093/jee/tou100.

AtK Based Literature Western US

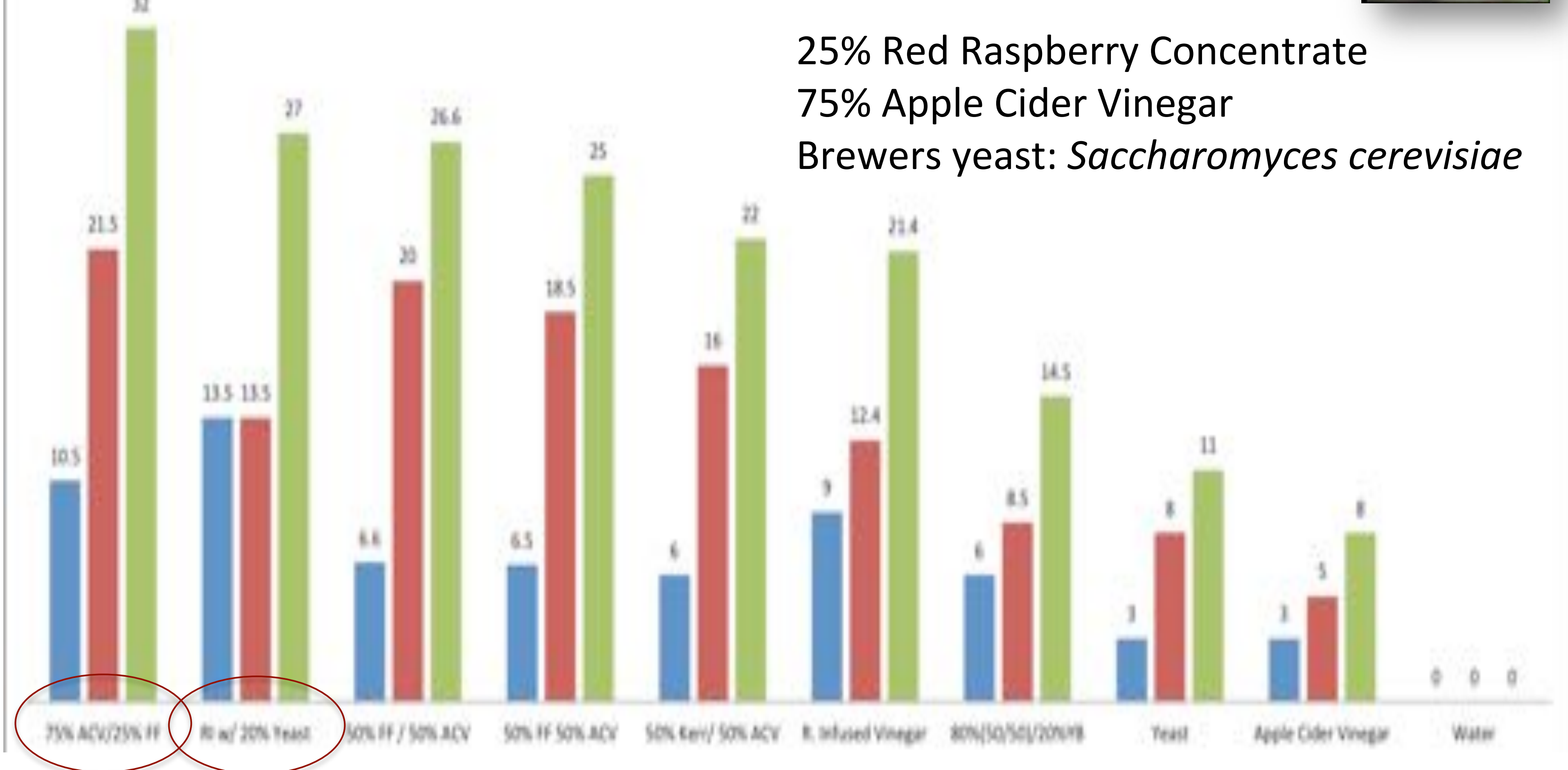
Alan L Knight, Esteban Basoalto, Wee Yee.   **Adding Yeasts with Sugar** to Increase the Number of Effective Insecticide Classes to Manage Drosophila suzukii (Matsumura) (Diptera: Drosophilidae) in Cherry
Pest Management Science · October 2015

Alan L Knight, Esteban Basoalto, Wee Yee. Developing a new bait for spotted-wing drosophila in organic cherry production
Acta horticulturae 1001(1001):147-152 · July 2013

Increased attractiveness of bait using bread yeast, Saccharomyces cerevisiae

- **Exceeds the attractiveness of commercial products GF-120® and Nu-Lure®,**
- **Addition of the sugar-yeast bait to Entrust increased fly mortality 4-fold in early-season bioassays with green and yellow cherries, reducing eggs laid and larval infestations by 50%**

SWD Adult Preference Binary Choice Tests
Mean # AtK Component Attractiveness



25% Red Raspberry Concentrate
75% Apple Cider Vinegar
Brewers yeast: *Saccharomyces cerevisiae*

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

AtK Construction

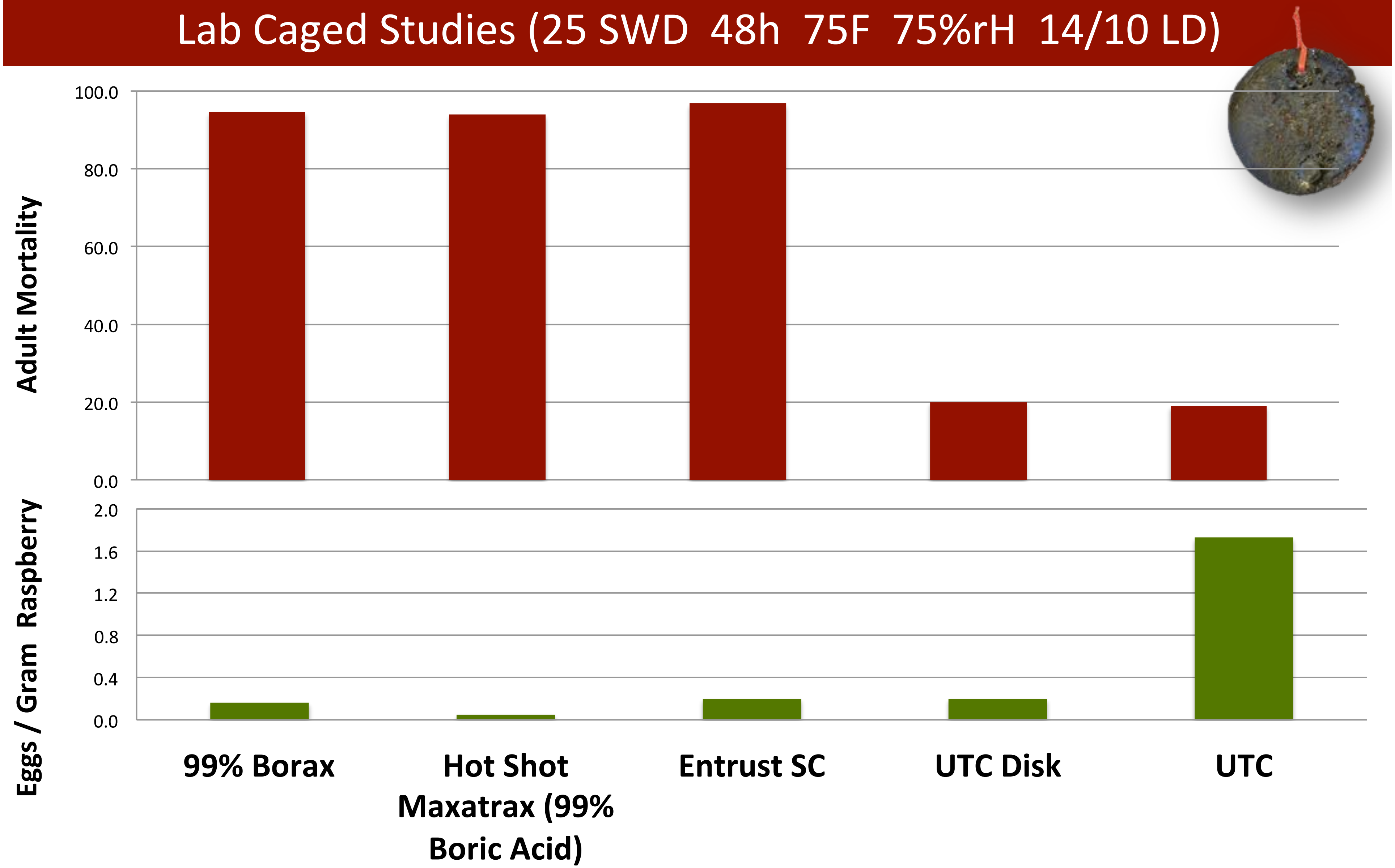
- 3” substrate woven polypropylene netting as a base
- Super Absorbent Polymer (SAP)
- Gelatin
- Red raspberry concentrate
- Apple cider vinegar
- Brewers yeast
- 1% A.I.
- AtK solution applied at 2 mL/disk

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

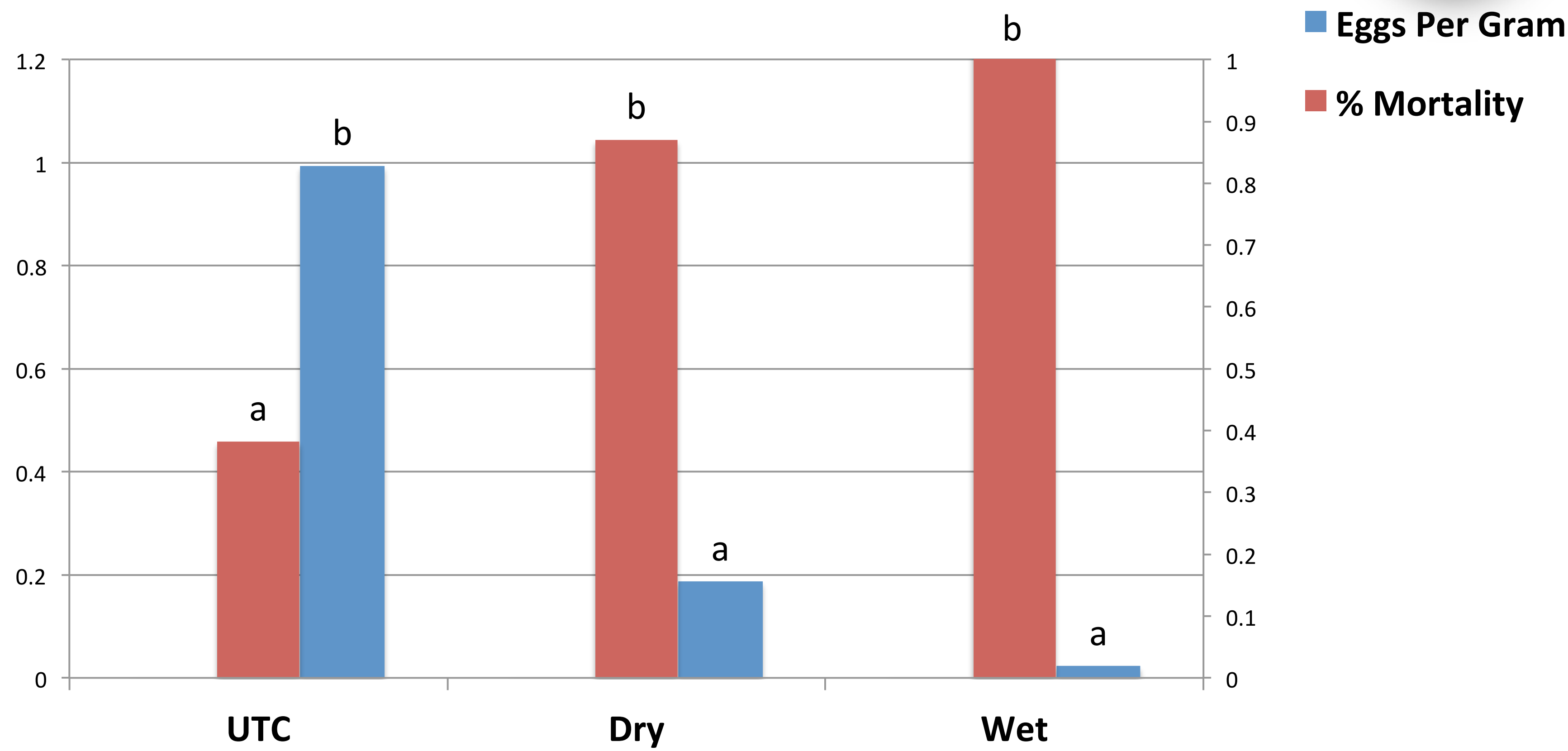
Attract and Kill Station Efficacy

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



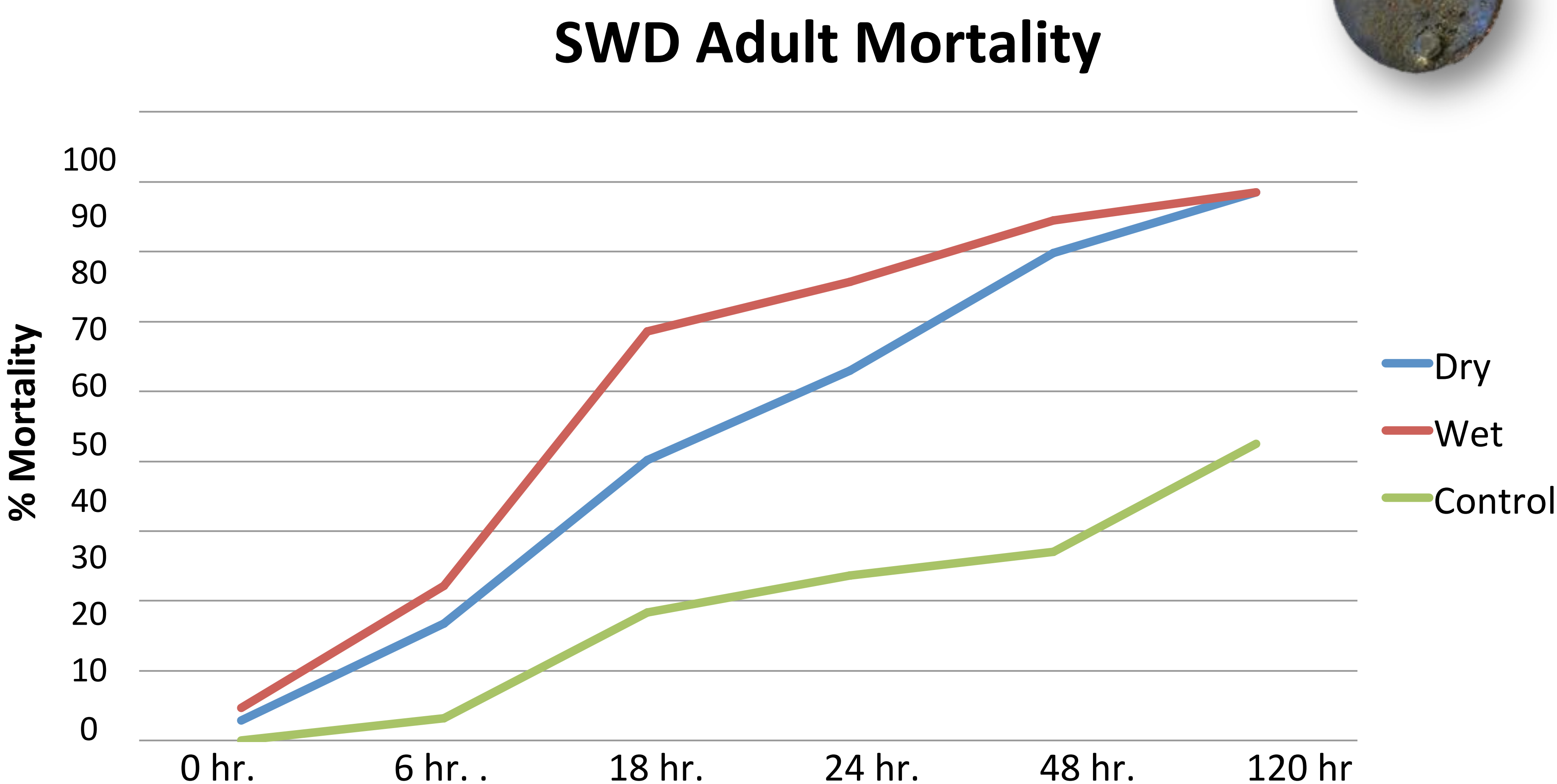
Attract and Kill Station Recharge Efficacy

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



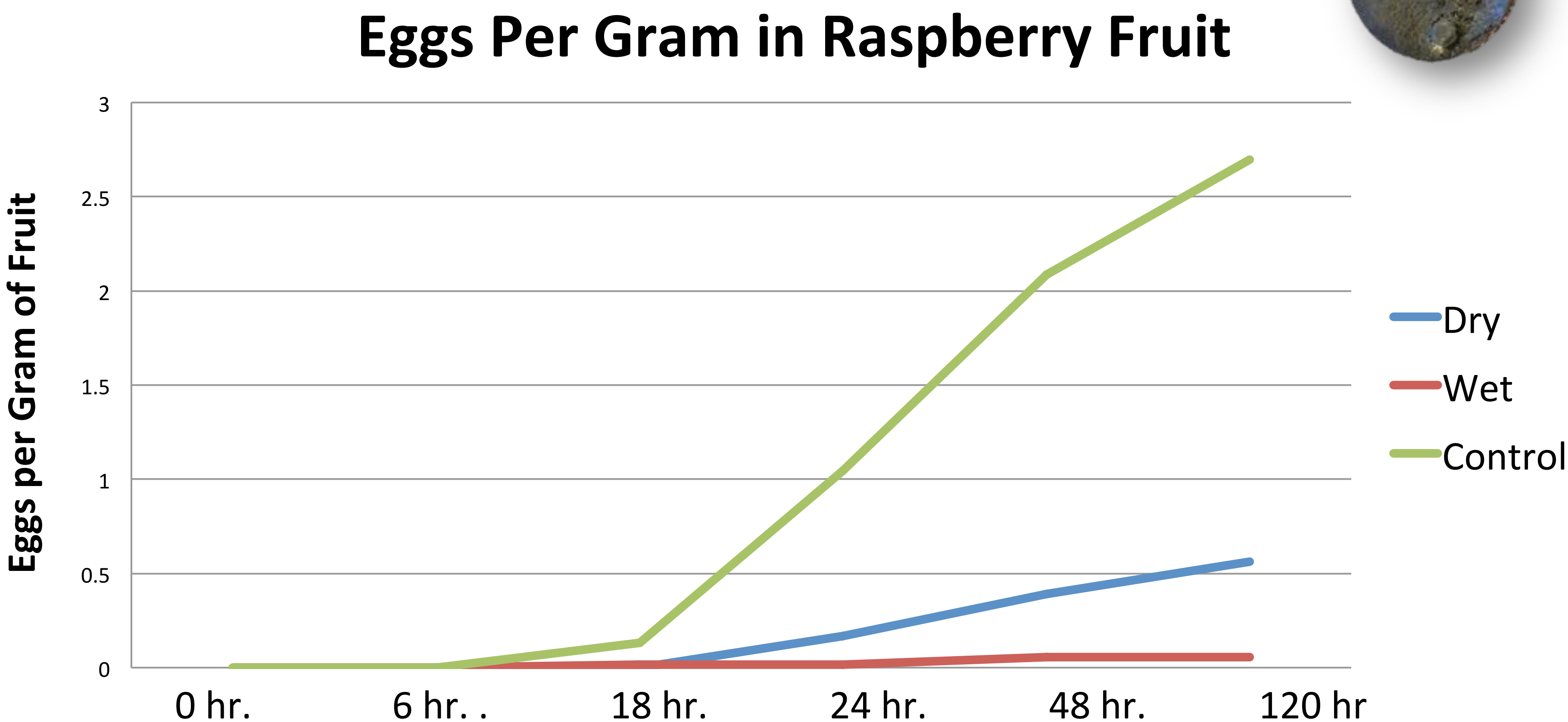
1% A.I. Entrust (spinosad-Dow)

Attract and Kill Station Recharge Efficacy



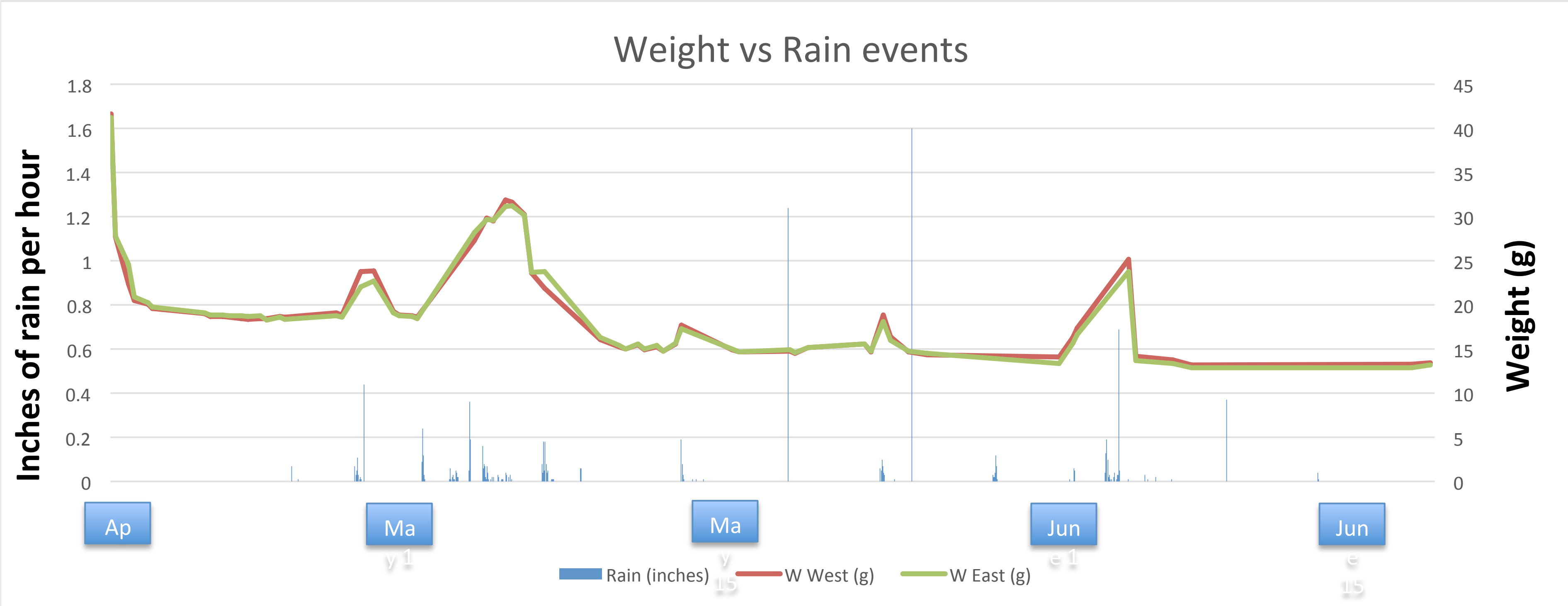
1% A.I. Entrust (spinosad-Dow)

Attract and Kill Station Recharge Efficacy



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

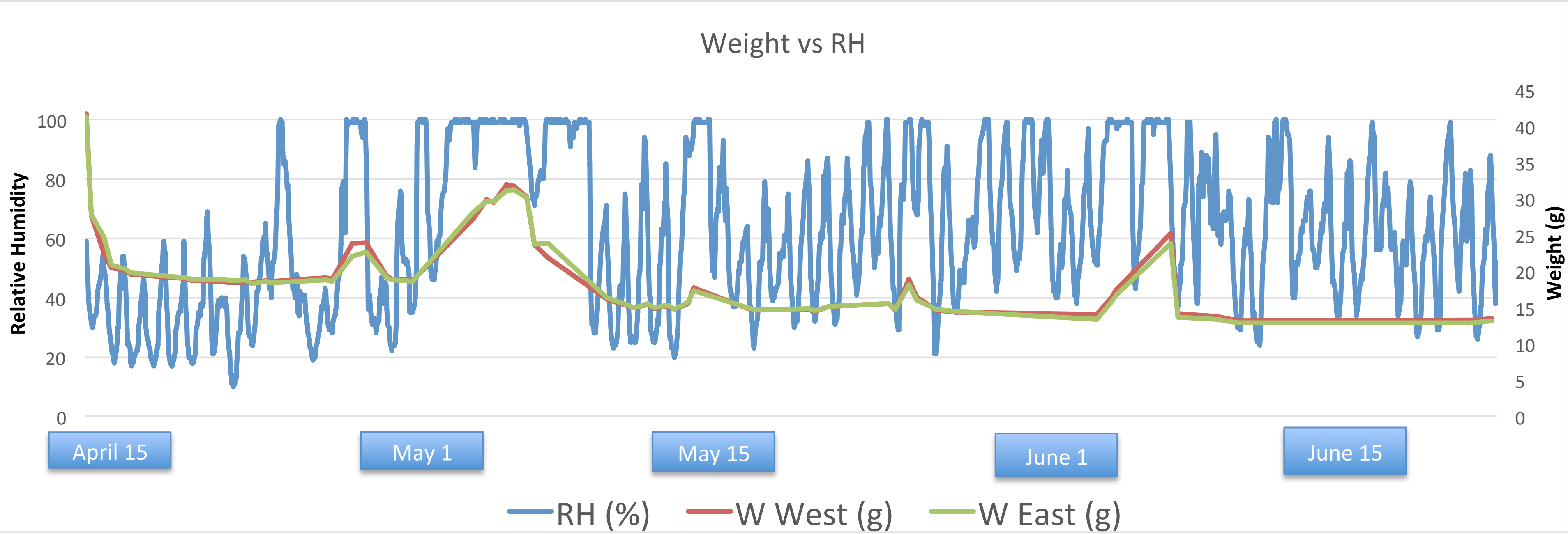
Insecticidal Options for AtK Stations



Observations

- Initial weight loss of $\geq$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



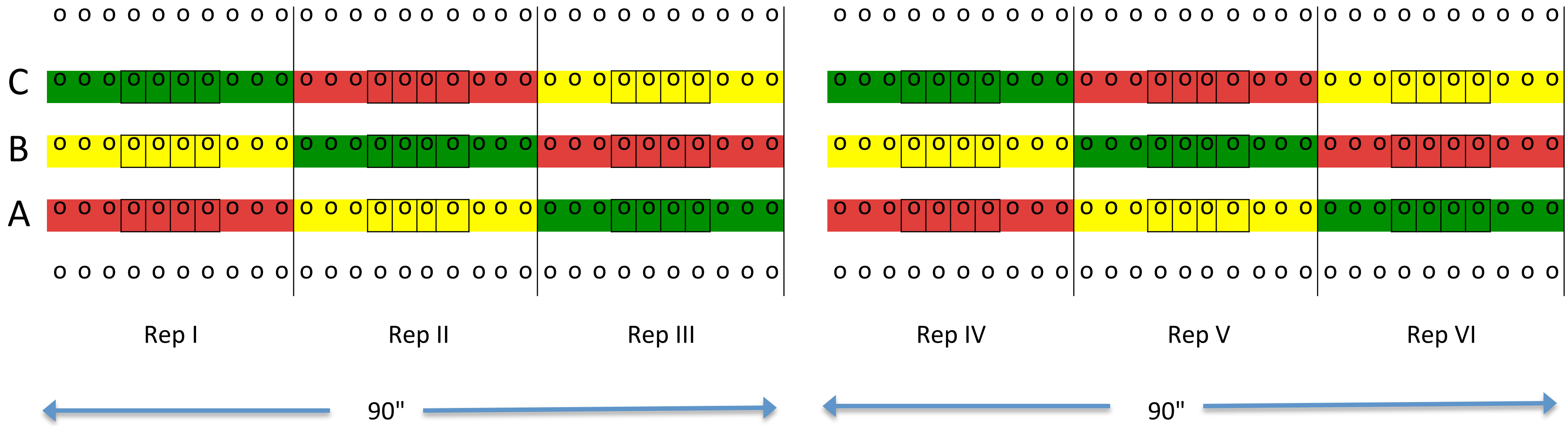
Observations

- 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*



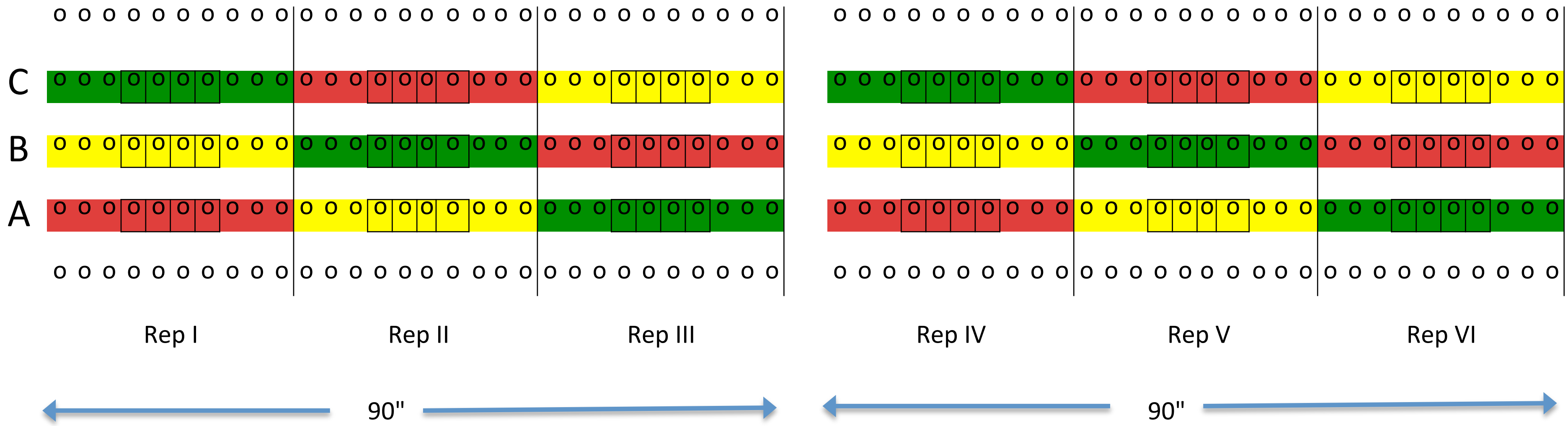
3 Raspberry Plantings on 3 Farm sites in two NY counties
1 Conventional & 2 Organic Production Systems

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



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)

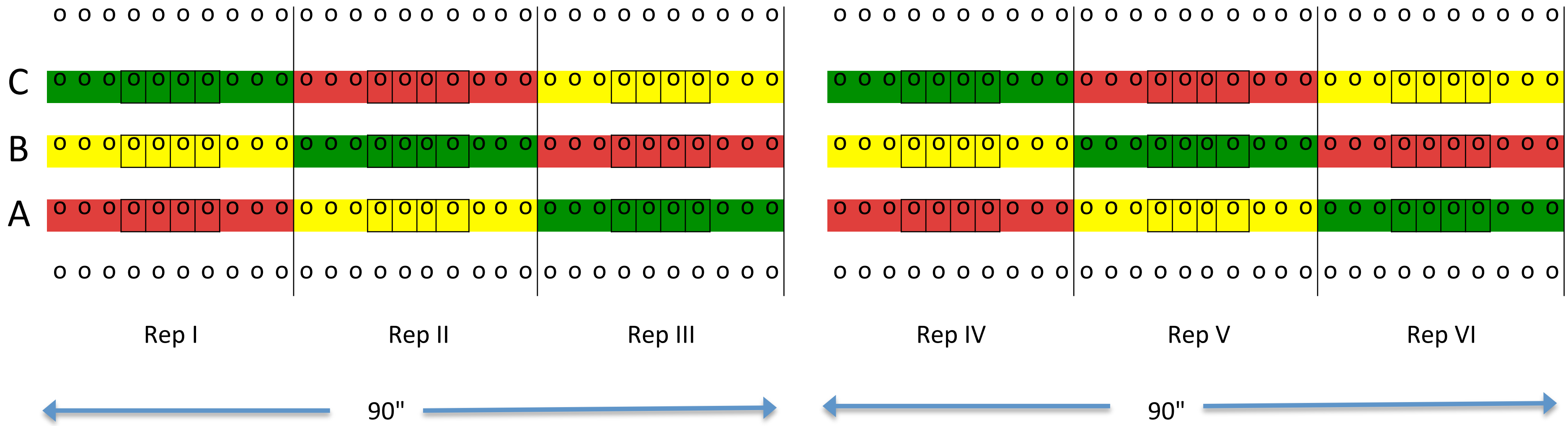
A. 1st SWD in NY (14th June)
B. 1st SWD on site (19th June)
C. 1st SWD oviposition of fruit (25th June)

Split Block

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

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

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)

Split Block

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

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

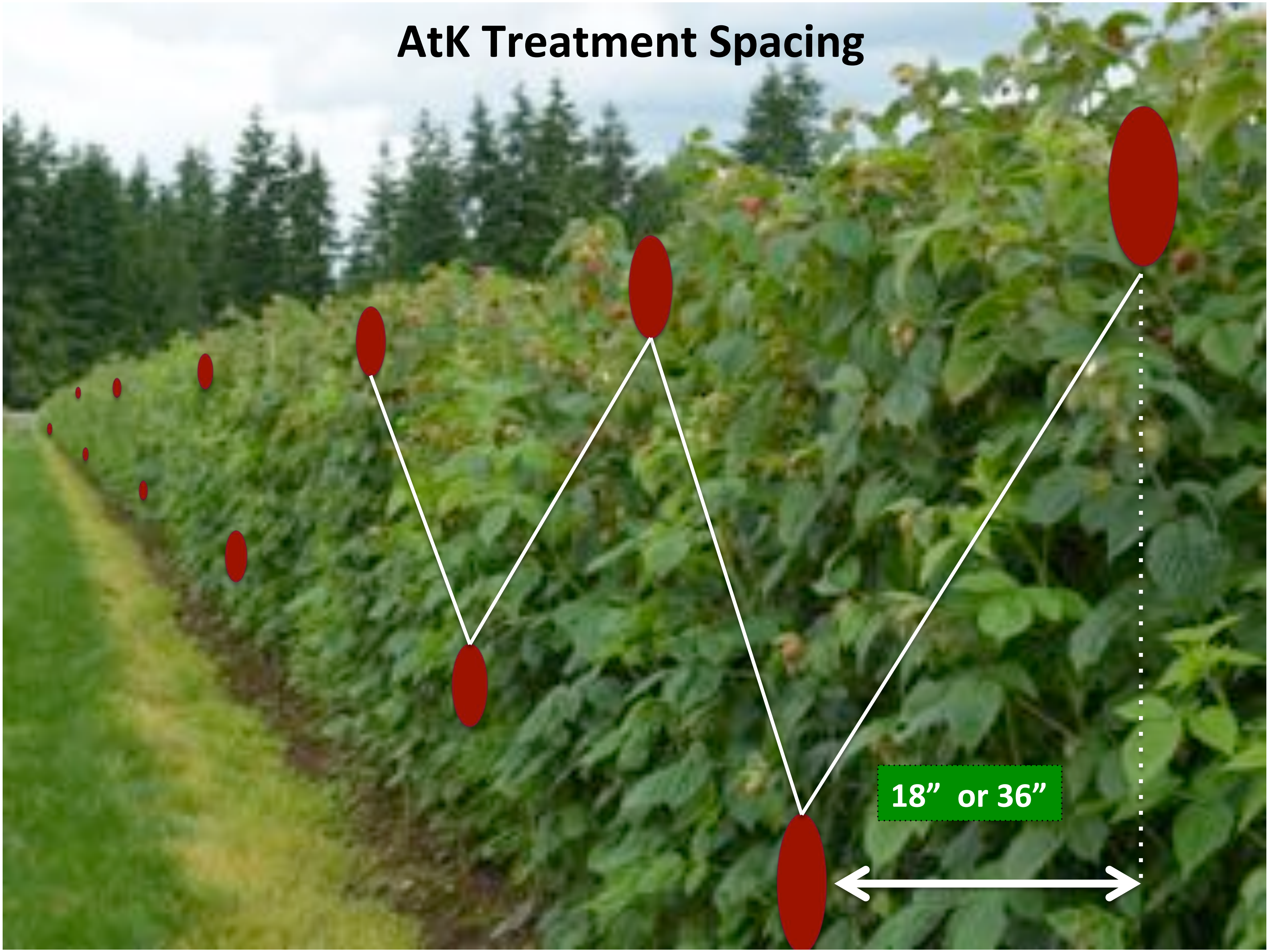
Treatments

Red O 1% Borax treated disks spaced at 1.5’ (120) Disks/ side = 240 disks/ row

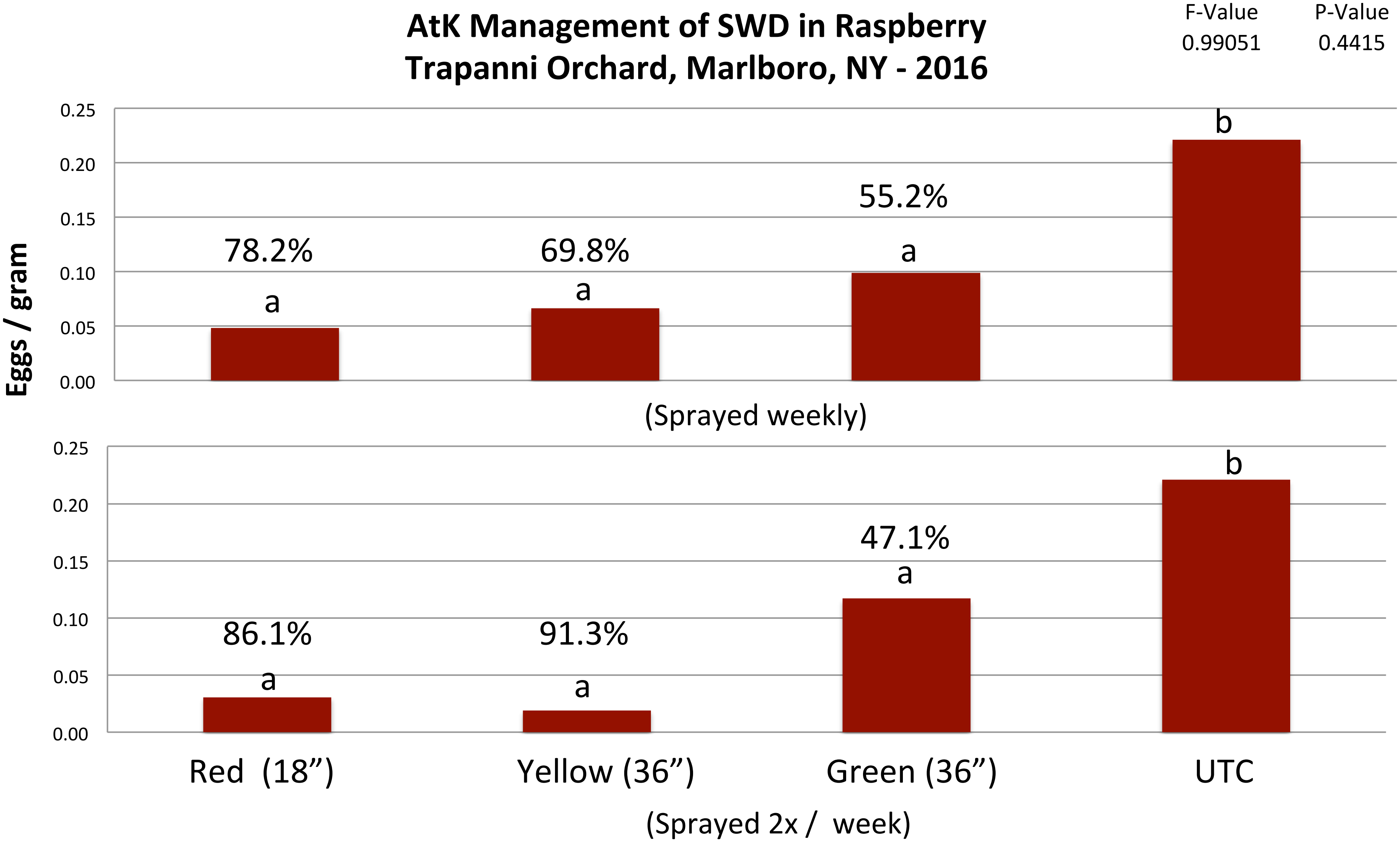
Yellow O 1% Borax treated disks spaced at 3’ (60) Disks/ side = 120 disks/ row

Green O Untreated disks spaced at 3’ (60) Disks/ side = 120 disks/ row

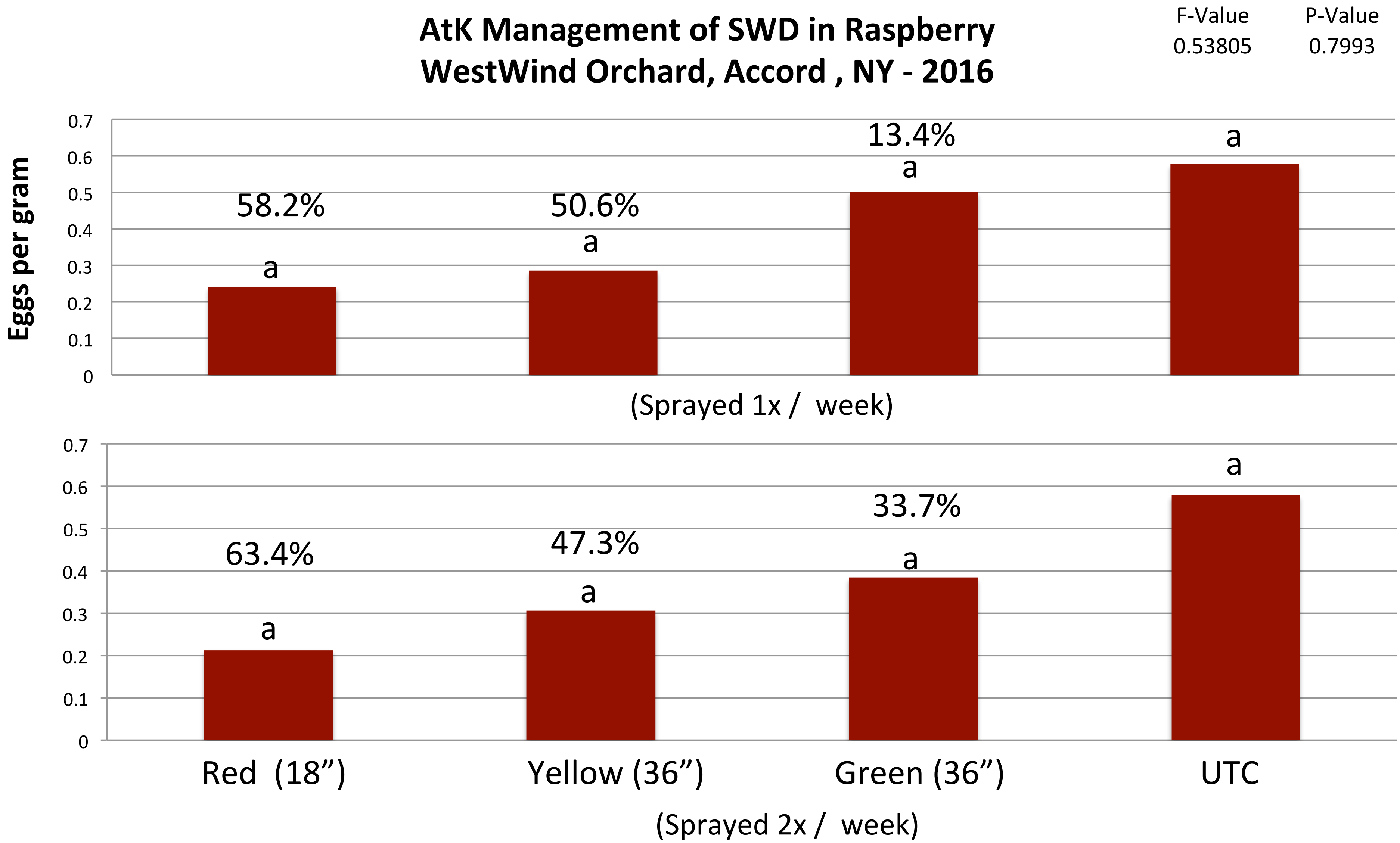
AtK Treatment Spacing



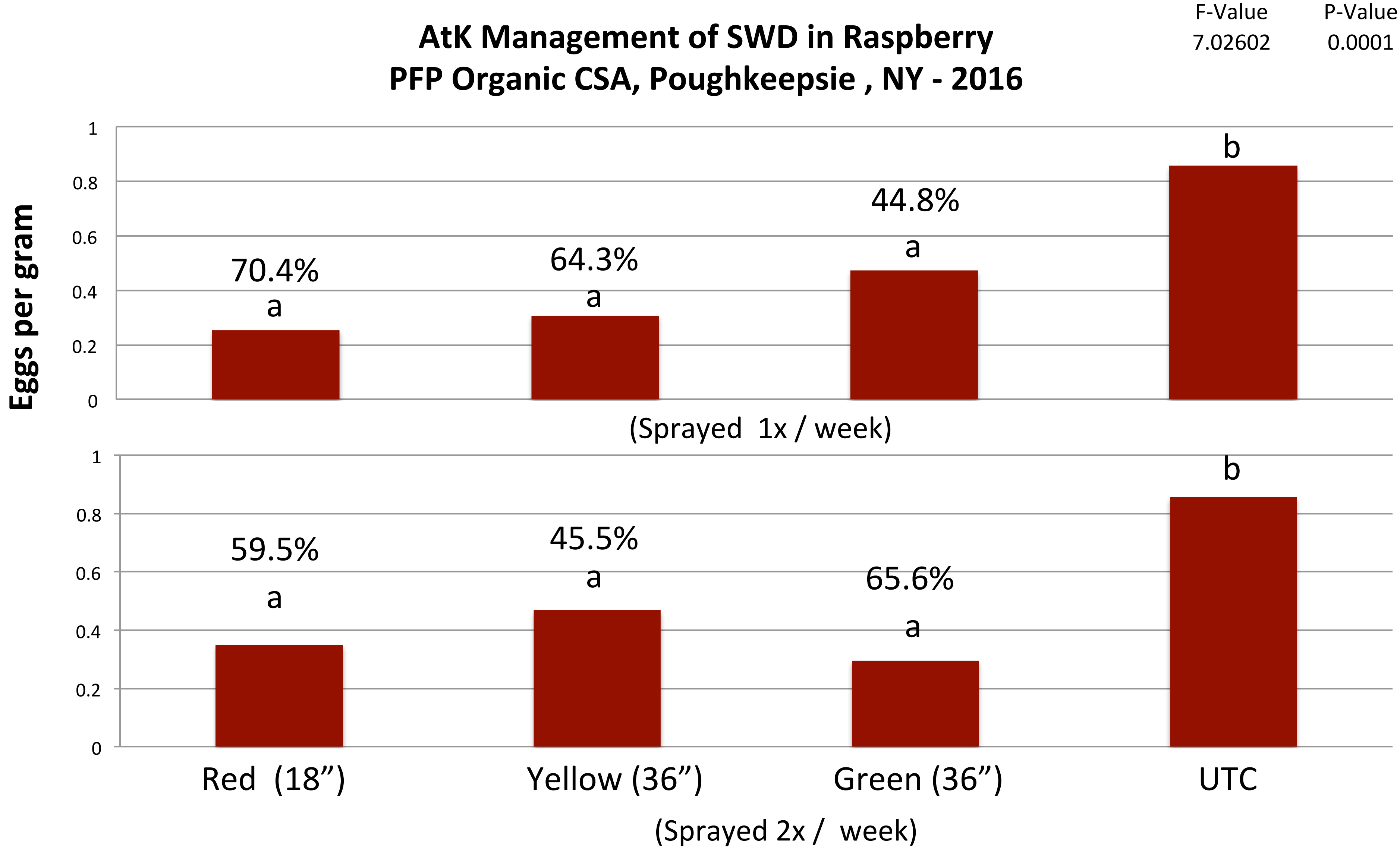
SWD Damage Means in Raspberry Fruit



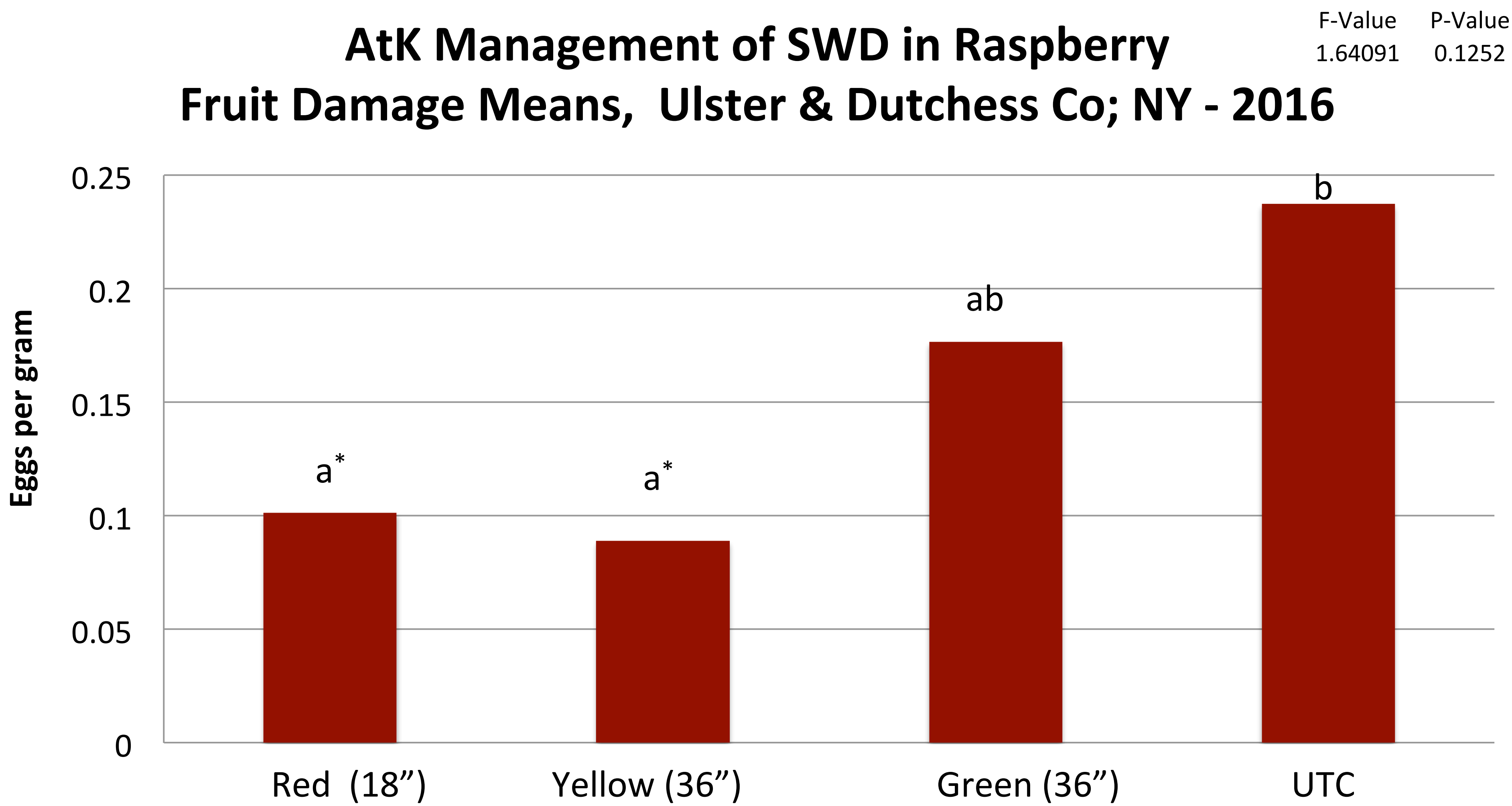
SWD Damage Means in Raspberry Fruit



SWD Damage Means in Raspberry Fruit



Combined Farm & AtK Application Timing



*59.9% Reduction of Raspberry Fruit Injury over the UTC

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.

Exclusion of SWD in Pick-Your-Own Production

Cornell University

Hudson Valley Research Laboratory

Our Objectives for Exclusion

1. Reduce SWD infestation to raspberry
2. Reduce chemical inputs for control
3. Provide easy access and plesent environment for PYO small fruit access
4. Reduce weed presence using grass/ weed free mat
5. Reduce cost: design structure to using wire
6. Dynamic structure design under wind conditions
7. Incorporate bumble bee pollination for increased fruit set
8. Provide optimum use of Attract and Kill solution for SWD management
9. Allow for biological control od SWD pupa
10. Reduced Bird Feeding: Allow for bird evacuation at open ends

Exclusion Costs in PYO Raspberry

SWD Exclusion / ATK System Costs	netted 20' wide 6.5' high at center and sides		
	Costs	Quantity	Costs
8' Posts	$9.80	6	$58.80
Netting	$732	5200sq.ft.	$732
High Tensile Wire	4000'/$90.00	1800	$40.50
30" Ground Anchors	$6.00	10	$60.00
4' Ground Anchors	$10.00	6	$60.00
Bushings	$0.01	4	$0.04
Zip Ties	$0.03	100	$3.00
Ground Cloth	$0.67	3600sq ft.	$240.00
Ground Cloth 6" Staples	$0.11	120	$13.20
Rachet ensioners	$4.50	6	$27.00
Gripple Tensioners	$1.50	12	$18.00
End Post Cams	$2.18	4	$8.70
Tubing	$0.23	10	$2.29
Binder Clips	$0.11	200	$22.22
4' Ground Conduit	$0.75	6	$4.50
10' Net Support Conduit	$1.75	10	$17.50
10' Post Separater Conduit	$1.75	2	$3.50
90 plumbing elbows	$0.6	6	$3.60
Sandbags	0.496666667	90	$44.70
Total material & labor costs			$1,359.55

Pollination Using Bumble Bee in PYO Raspberry

Summary: Exclusion net

- Exclusion net in ‘Pick-Your-Own’ production requires proper height and width spacing to accommodate customer comfort.
- Pollination / H.bees may interfere with PYO comfort
- Costs for 200' row netted 20' wide 6.5' high at center and sides = $1707.00 ($854.00 / 100’).
- Net longevity approximately 7 years ($244.00 / year)
- Exclusion efficacy requires 100% exclusion; realistically
- Attact and Kill to manage SWD in exclusion net systems increase costs to $58.00 / 100’.

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

Research Support Specialist I	Dana Acimovic
Laboratory Technician	Lydia Brown
Research Assistant	Christopher Leffelman
Research Assistant	Lucas Canino
Farm Manager	Albert Woelfersheim
Administrative Assistant	Erica Kane
Administrative Assistant	Christine Kane
HRVL & NEWA Weather Data..............................	Christopher Leffelman, Albert Woelfersheim

Support from NYS Ag. & Mkts SCRI, Dow AgroSciences, Bayer,
NY Farm Viability Institute, NYS Orchards & Farmers (ARDP)