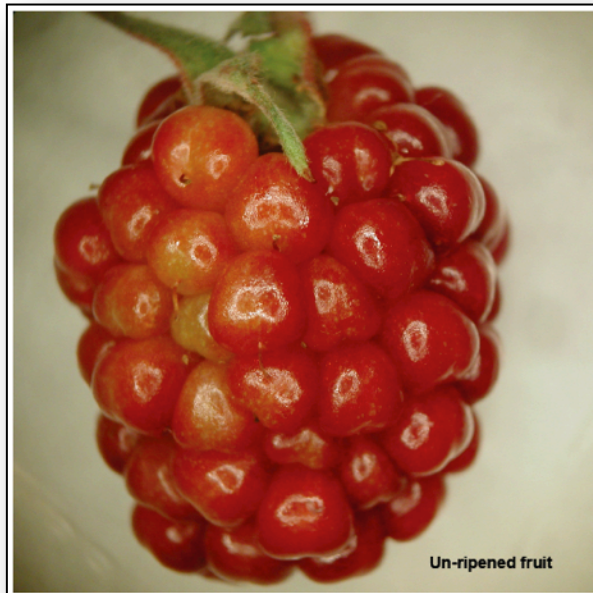


Invasives in Small Fruit: Spotted Wing Drosophila



SWD Adult Male



Infected Blackberry



Fruit Fly Egg 'Respiratory Horns'

2015 Hudson Valley Commercial Fruit Growers' School

Best Western Plus

Kingston, NY

February 12th, 2015

Peter Jentsch

Senior Extension Associate – Entomology

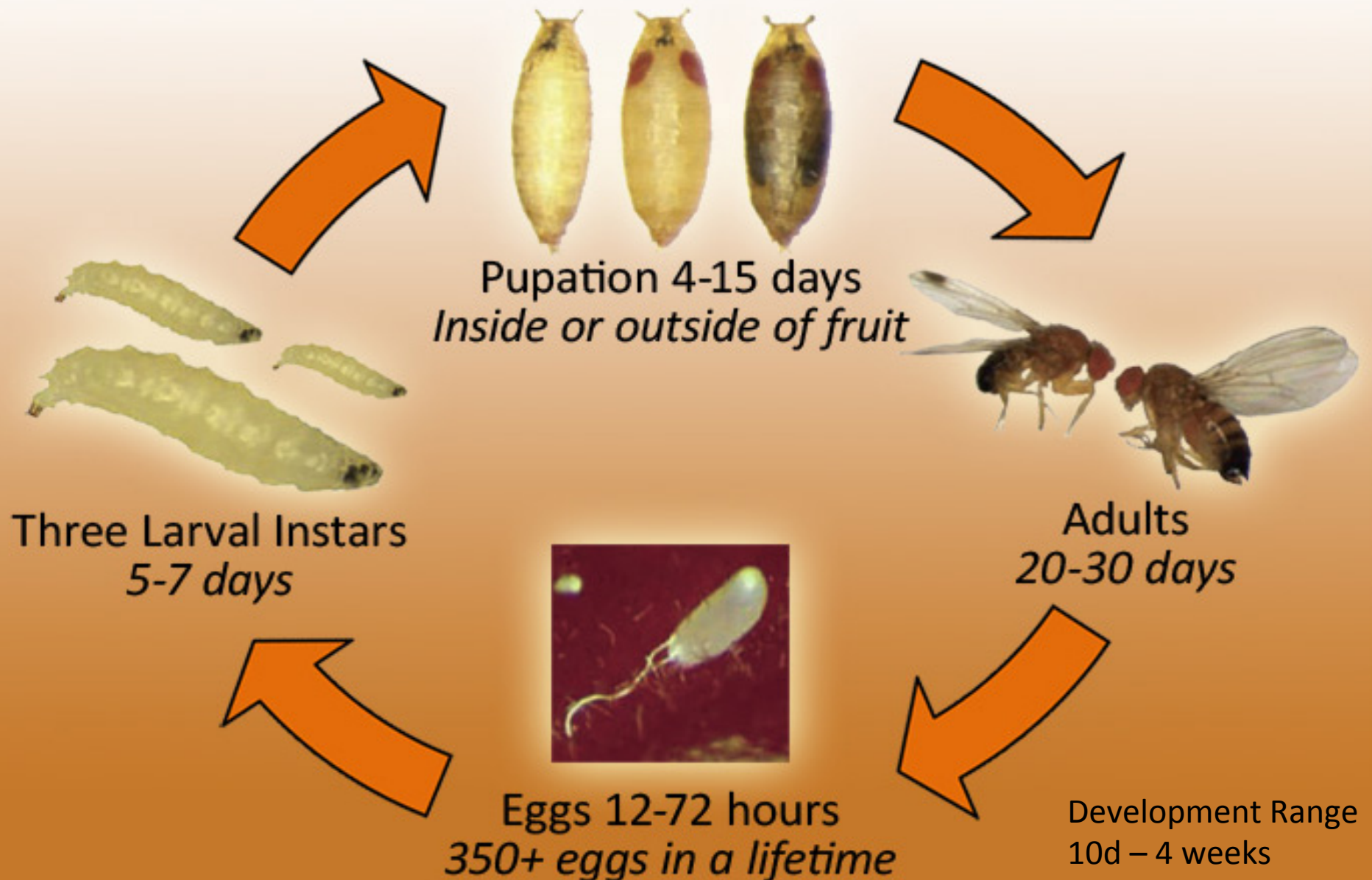


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Hudson Valley Research Laboratory

Life Cycle of the Spotted Wing Drosophila

Drosophila suzukii (Matsumura)



Female *Drosophila* species

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

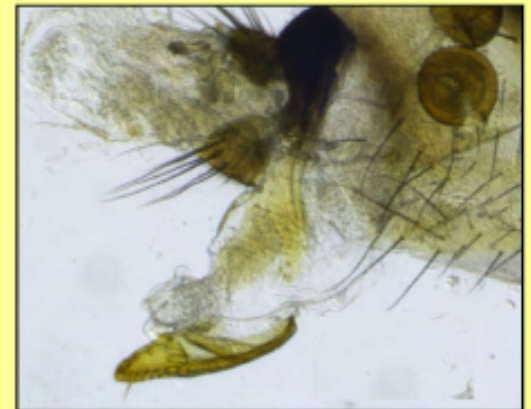
Spotted Wing *Drosophila* (*D. suzukii*)



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



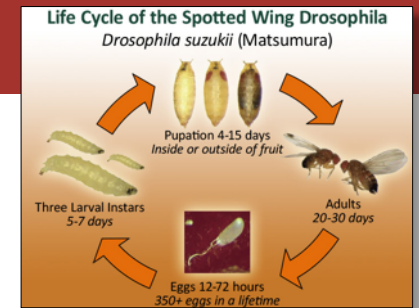
Leading edge of
wing has dark spot



Unbroken abdominal bands

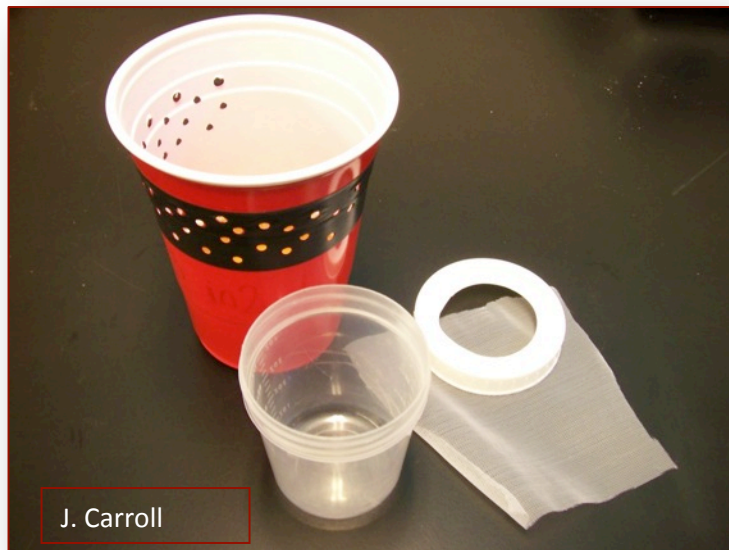
Factors Contributing to Insecticide Resistance

- Single cycle in 10d to 4 weeks
- 13 generations / year (Japan)
- Range of 3-10 generations in NY
- SWD has a very high probability of insecticide resistance development.



Monitoring Adult SWD

- **Whole wheat bread dough (fermenting bait)**
 - water, sugar, yeast, whole wheat, apple cider vinegar (ACV)
 - drowning solution of ACV



- Salt flotation for monitoring larva in fruit

Male Spotted Wing Drosophila (SWD)

UC Berkeley & UC Cooperative Extension

Photos: M. Hauser, CDFA



Double stripes on
tarsi of front legs

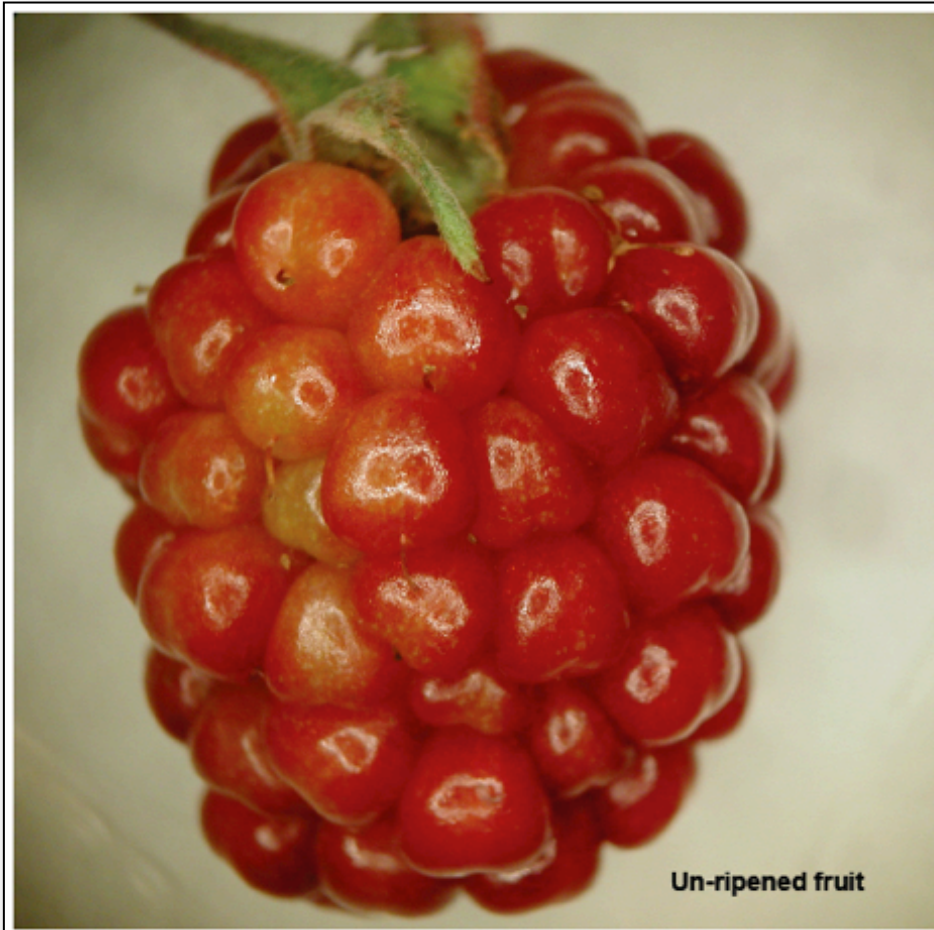


Leading edge of
wing has dark spot



Unbroken abdominal bands

Spotted Wing Drosophila Fruit Infestation



Pre-mature Blackberry



Spotted Wing Drosophila Fruit Infestation

Berries collapse within days of infestation.

In 5 days larvae are evident.



Slide Credit: Laura McDermott



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Spotted Wing Drosophila Fruit Infestation

- 5 days after egg laying
- visible dark scarring and fruit collapse



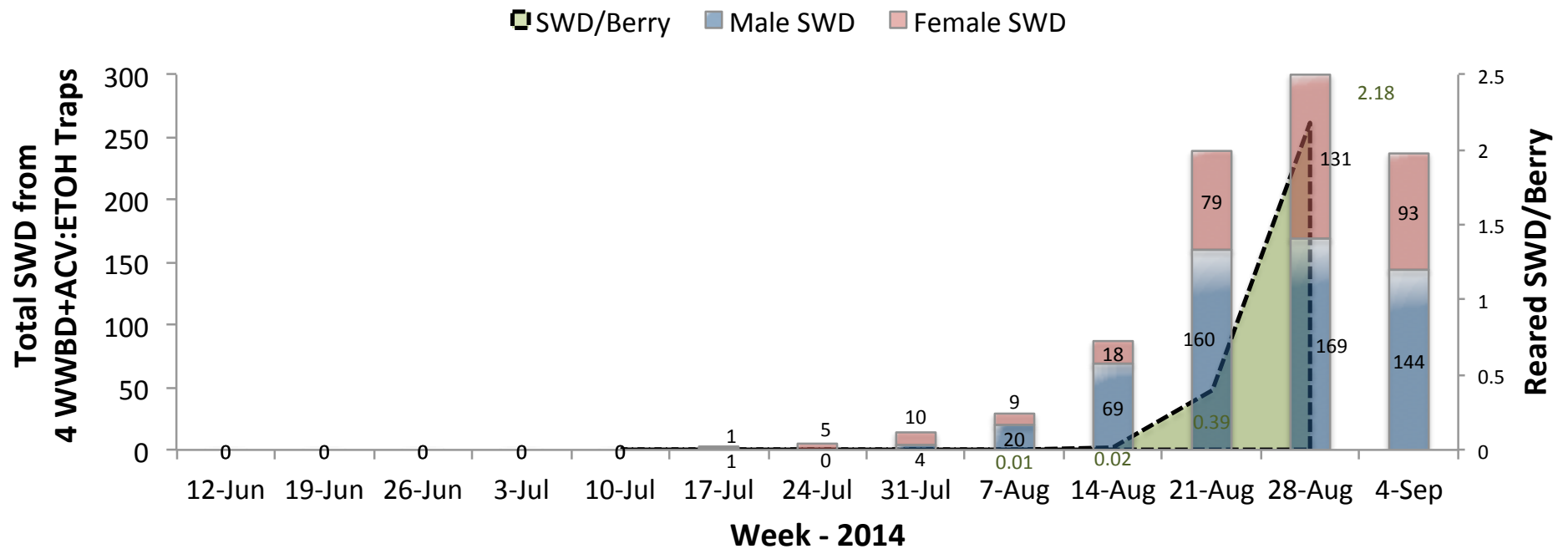
Photos: J. Carroll, NYS IPM



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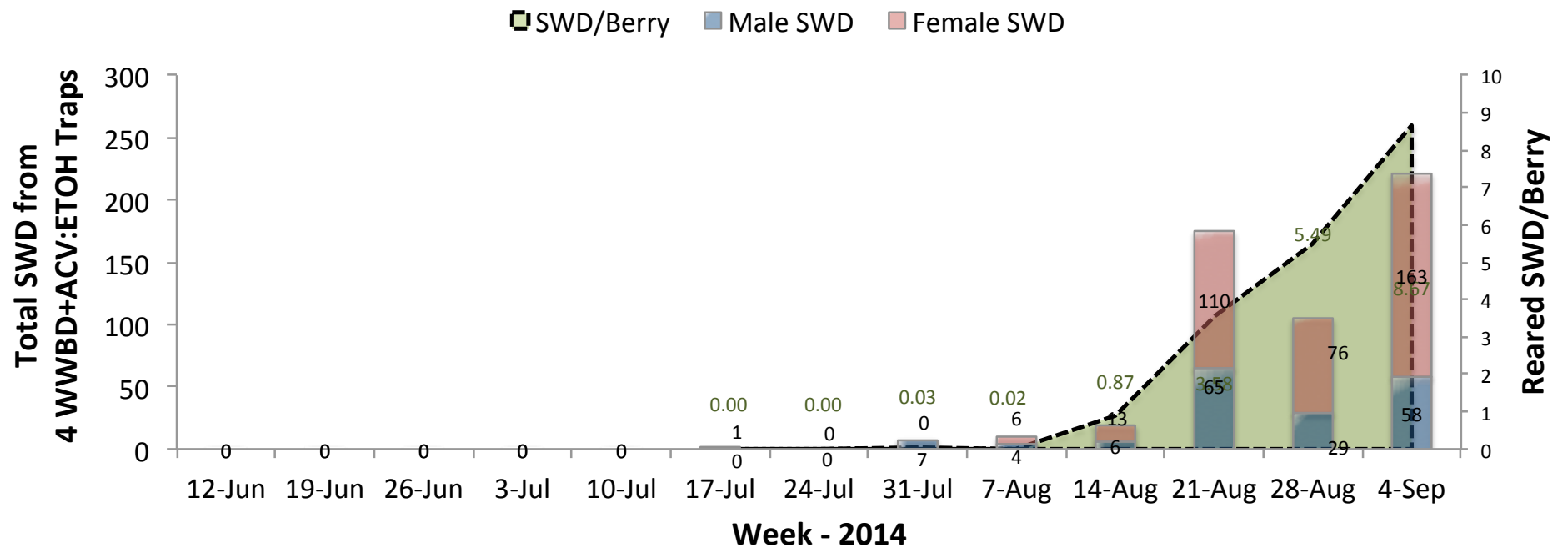
Hudson Valley Research Laboratory

Comparison of Monitoring Trap Captures and Fruit Infestation Levels Blueberry - Site RPE



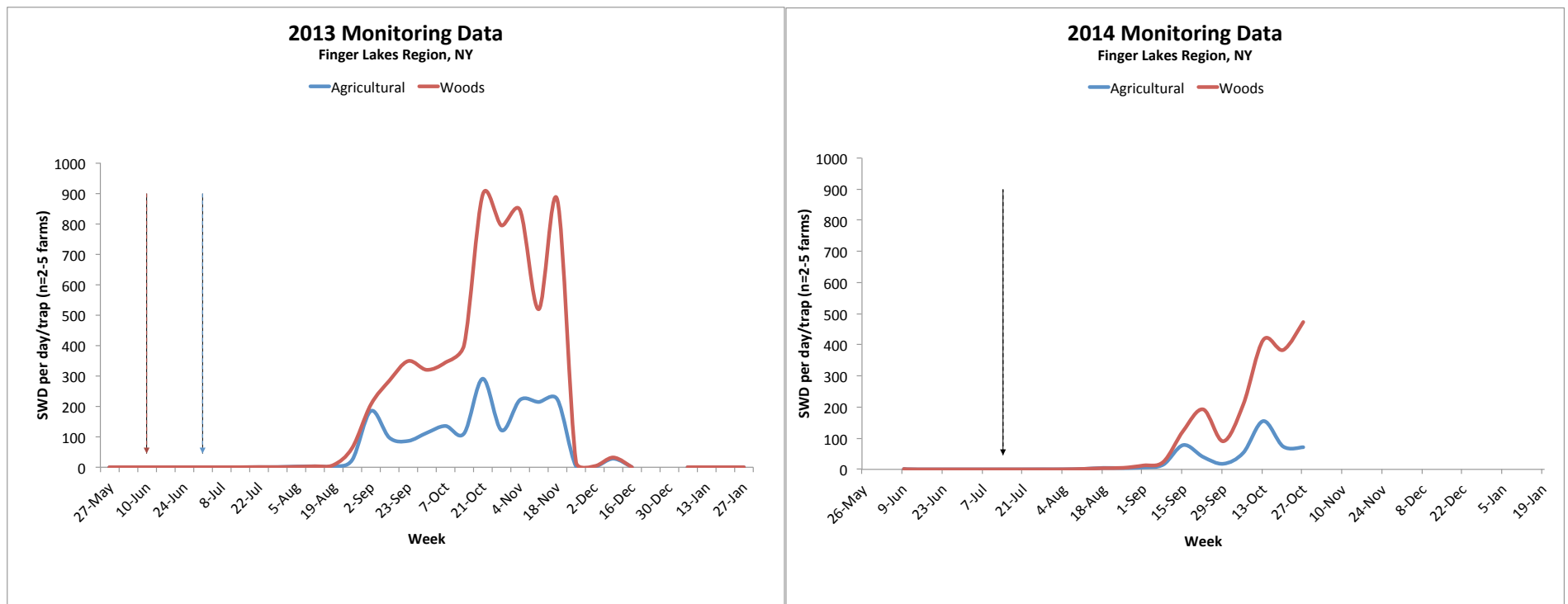
Credit: Greg Loeb Lab, NYSAES Geneva, NY

Comparison of Monitoring Trap Captures and Fruit Infestation Levels Raspberry - Site SQ



Credit: Greg Loeb Lab, NYSAES Geneva, NY

SWD SEASONAL DYNAMICS IN THE NORTHEAST



Credit: Greg Loeb Lab, NYSAES Geneva, NY

CLASSES OF SWD INSECTICIDES

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

***Just received EPA label for blueberries, not raspberries**

Credit: Greg Loeb Lab, NYSAES Geneva, NY

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

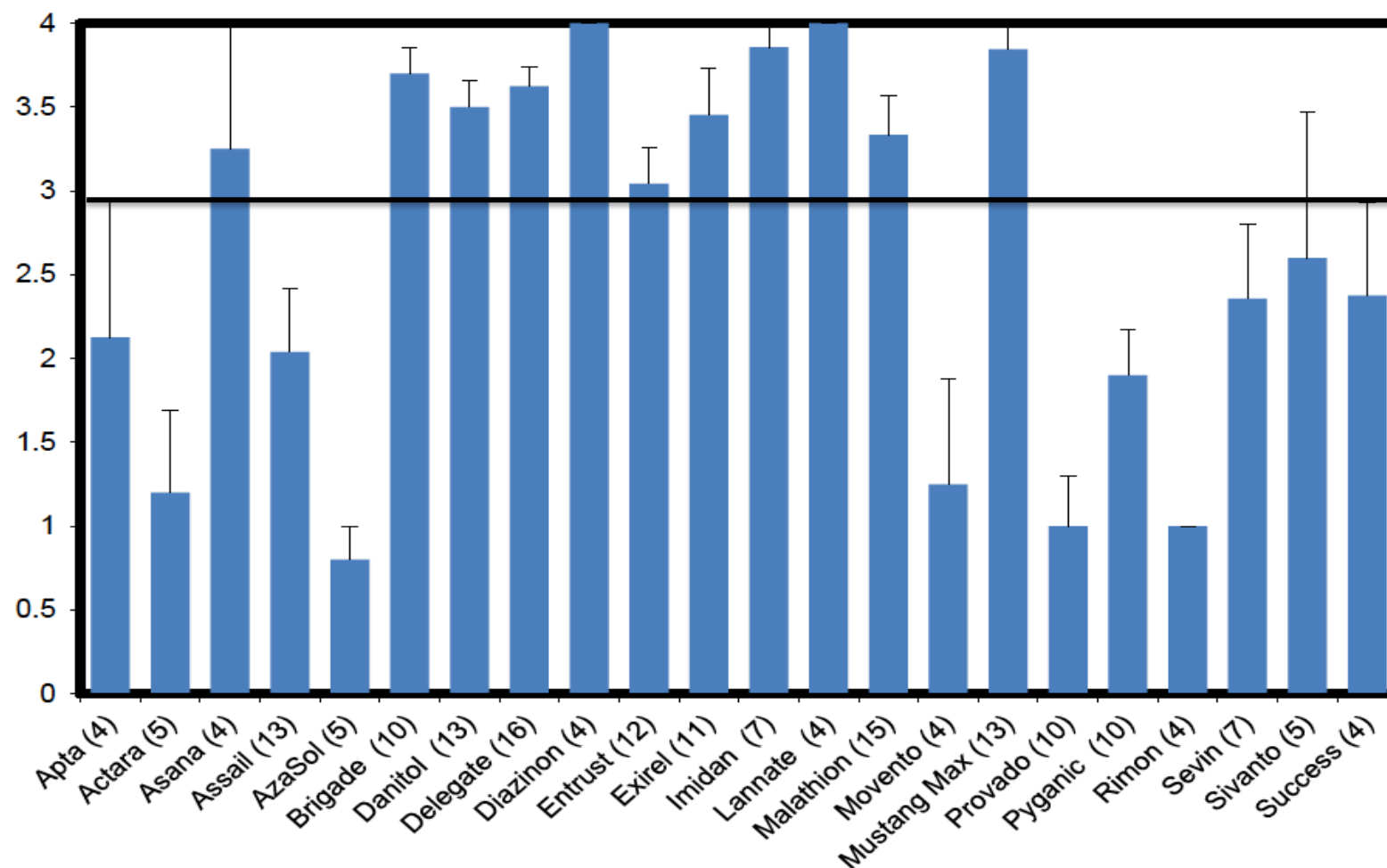
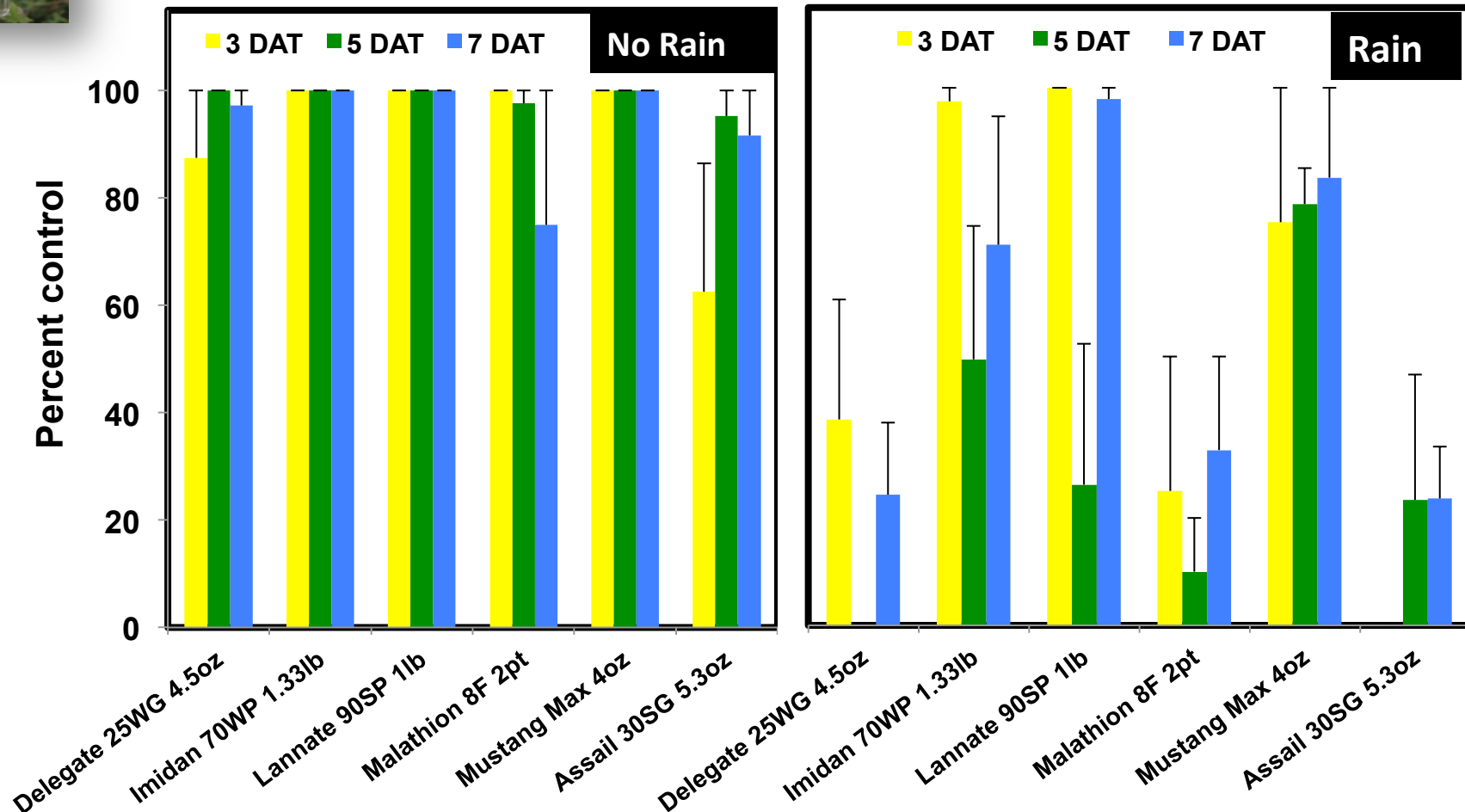


Figure 1. Average \pm S.E. efficacy rankings for 22 insecticides that have been tested against SWD in various fruit crops. Insecticides were ranked as not effective (score = 0), weakly active (1), fair (2), good (3), or excellent (4). Only insecticides that had 4 or more submitted are included in the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

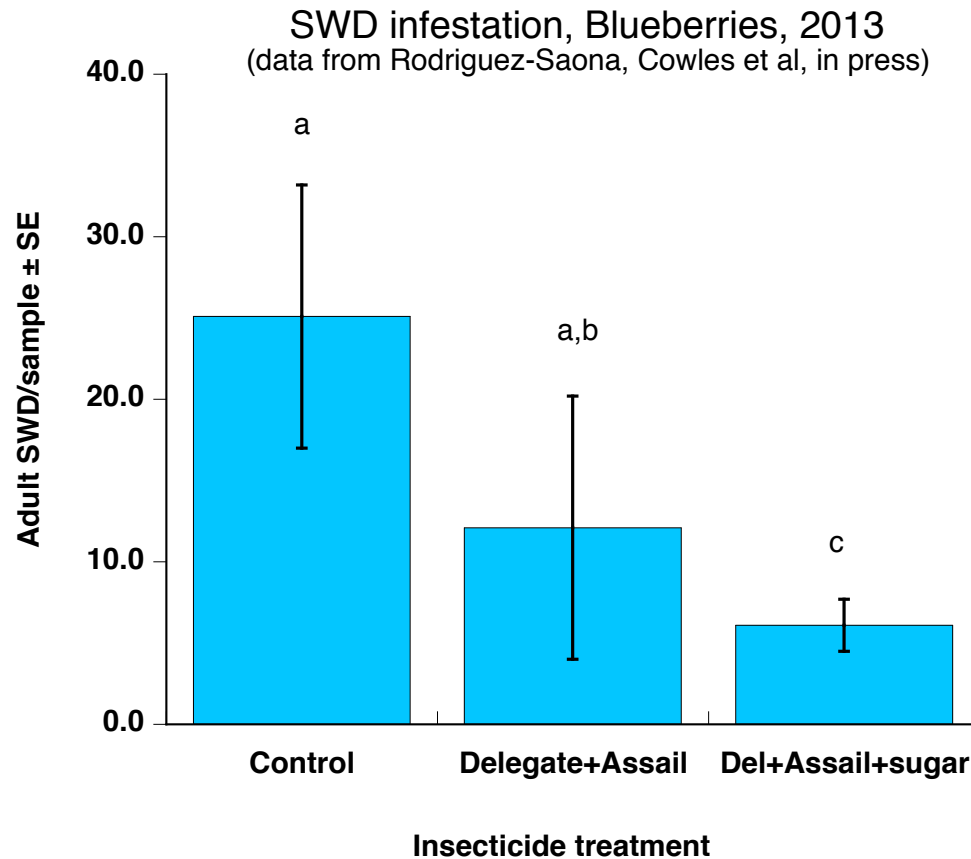
Effect of Rain on Some Common Insecticides

From Rufus Isaacs, MSU



*0.8 inches of rain on treated bushes
1 day after application*

Enhancing Mortality with Sugar



Cultivar: 'Bluecrop'

Treatments: 4 wk spray program

-Alternate Delegate & Assail

-Delegate & Assail plus sugar

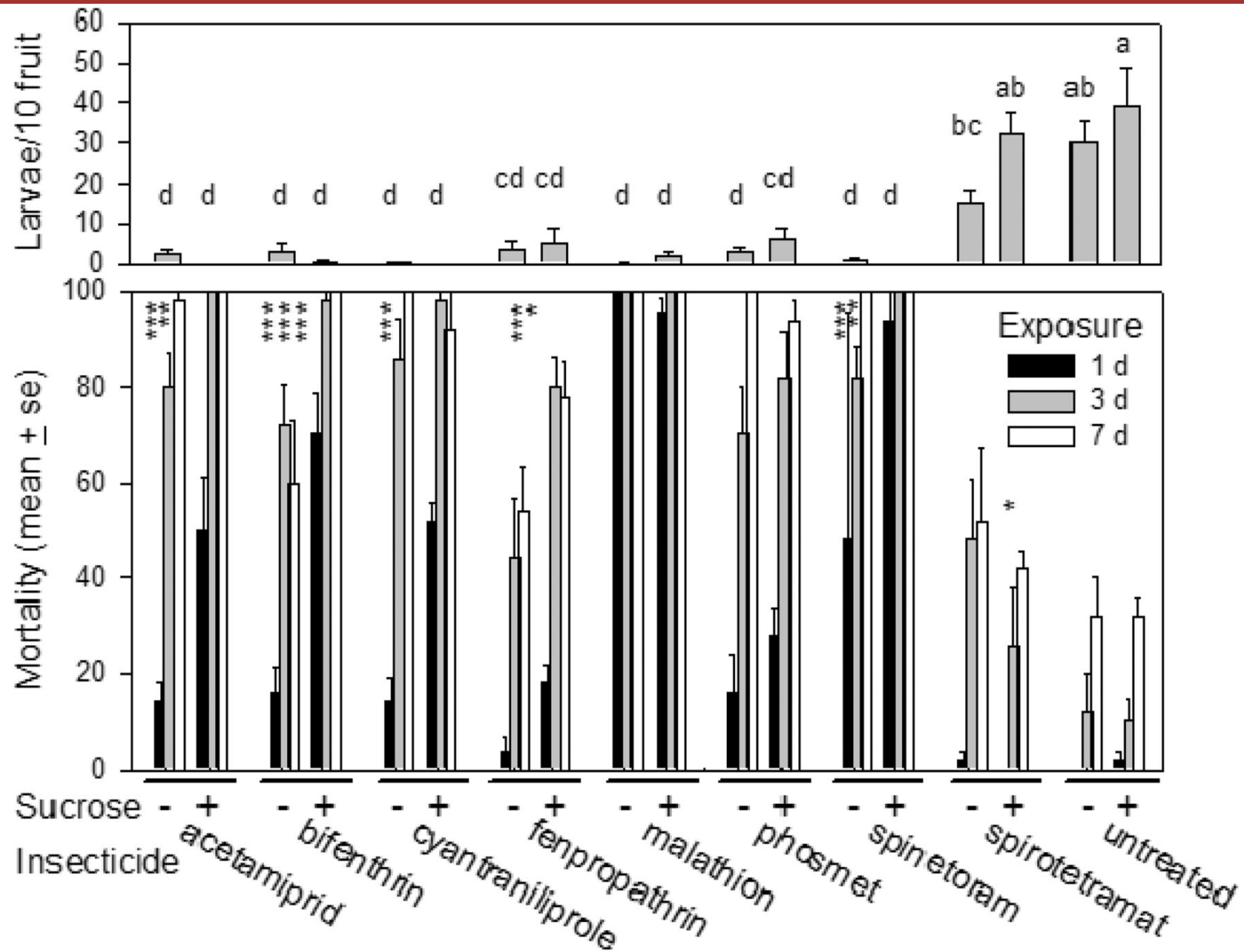
Plot size: 2 rows, 32 bushes

Replicates: 4

Sugar: 2 lb. / 100 gal.

Sucrose Improves Insecticide Activity Against *Drosophila suzukii* (Diptera: Drosophilidae)

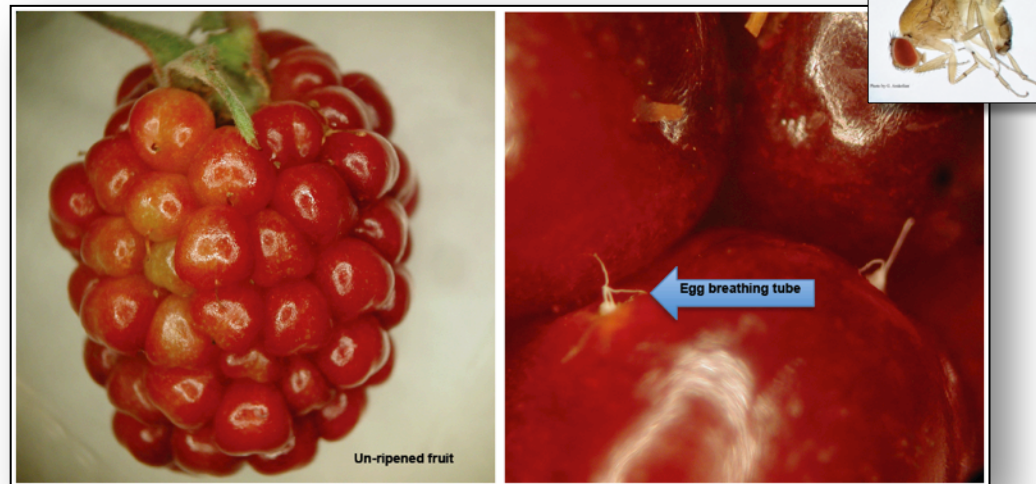
Richard S. Cowles , Cesar Rodriguez-Saona , Robert Holdcraft , Gregory M. Loeb , Johanna E. Elsensohn , Steven P. Hesler



SUMMARY

- Insecticides are presently the primary method of control for SWD
- Consider rotating insecticide IRAC classes every 10-14 days to maintain insecticide susceptibility
- Consider the weather forecasts and insecticide to maintain residual activity
- Sugar may increase efficacy of some insecticides

Post Harvest Study: Control of SWD After Harvest



Peter Jentsch
Senior Extension Associate – Entomology



Cornell University
College of Agriculture and Life Sciences

Hudson Valley Research Laboratory

Post Harvest Study: Control of SWD In Raspberry After Harvest

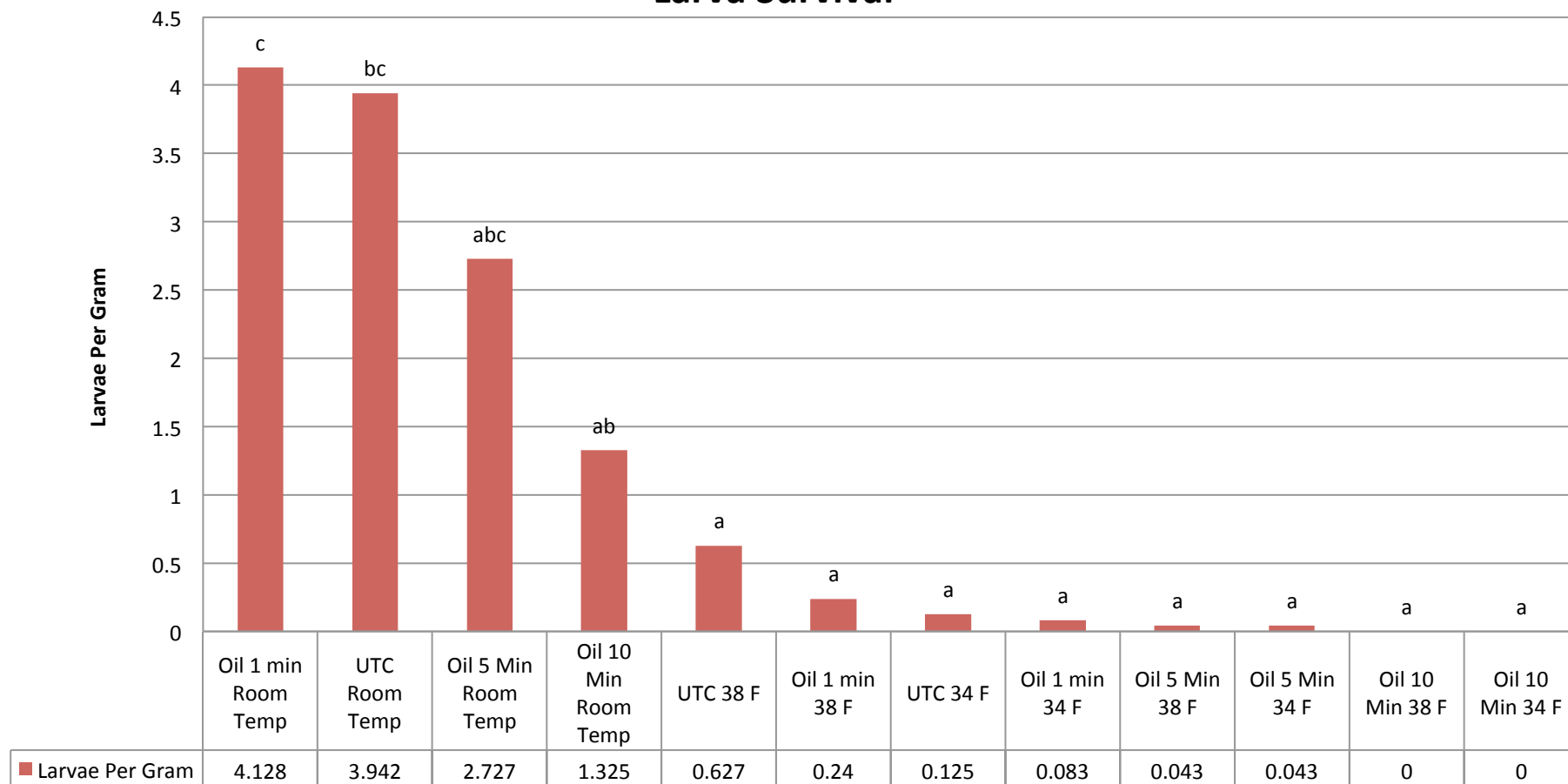
Larval survival in fruit is temperature dependent.

- Low temperature can reduce the post-harvest impact of larval survivability in raspberry
- Fruit exposed to temperatures at 34F and 38F for 72 hours showed significant impact on larval survivors.
- Use of 1% horticultural oil showed reduced survivors when fruit is immersed for 5 and 10 minutes with fruit held at 34F & 38F for 72 hrs. providing nearly 100% larval mortality.



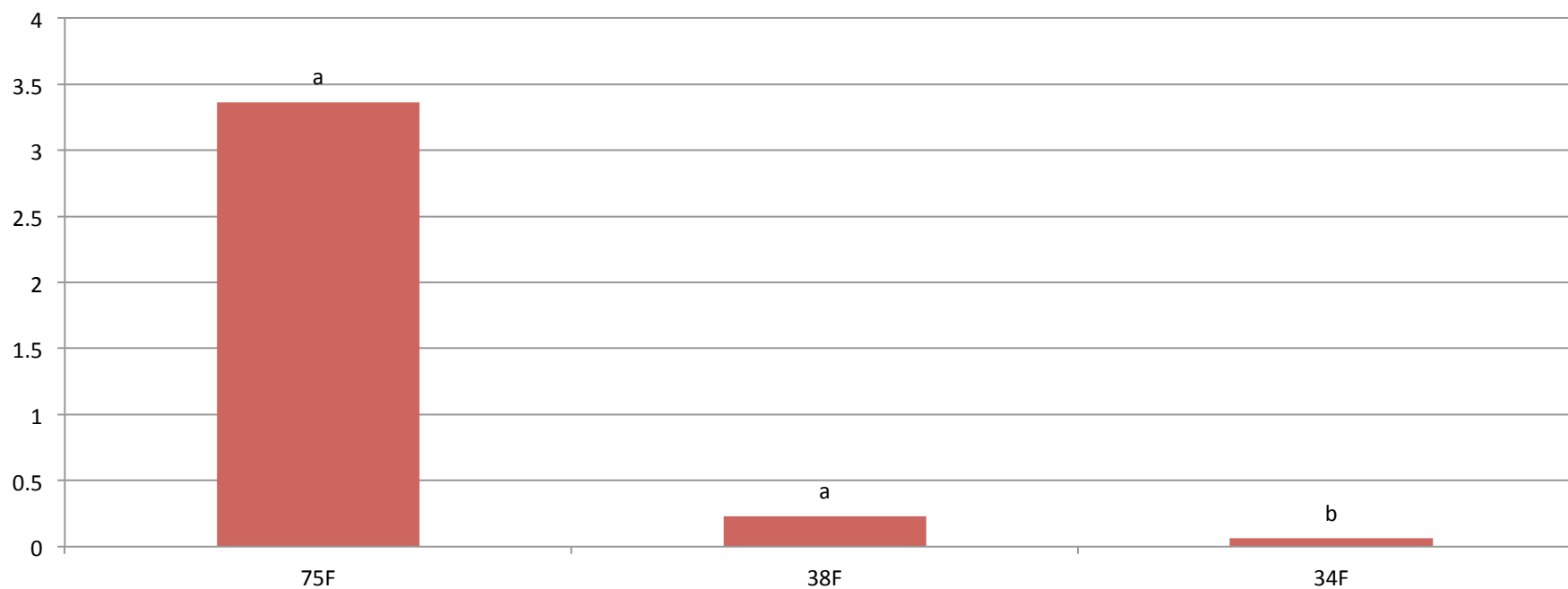
Post Harvest Study: Control of SWD In Raspberry After Harvest

Evaluating Low Temperature & 1% Oil Immersion of Raspberry on SWD Larva Survival



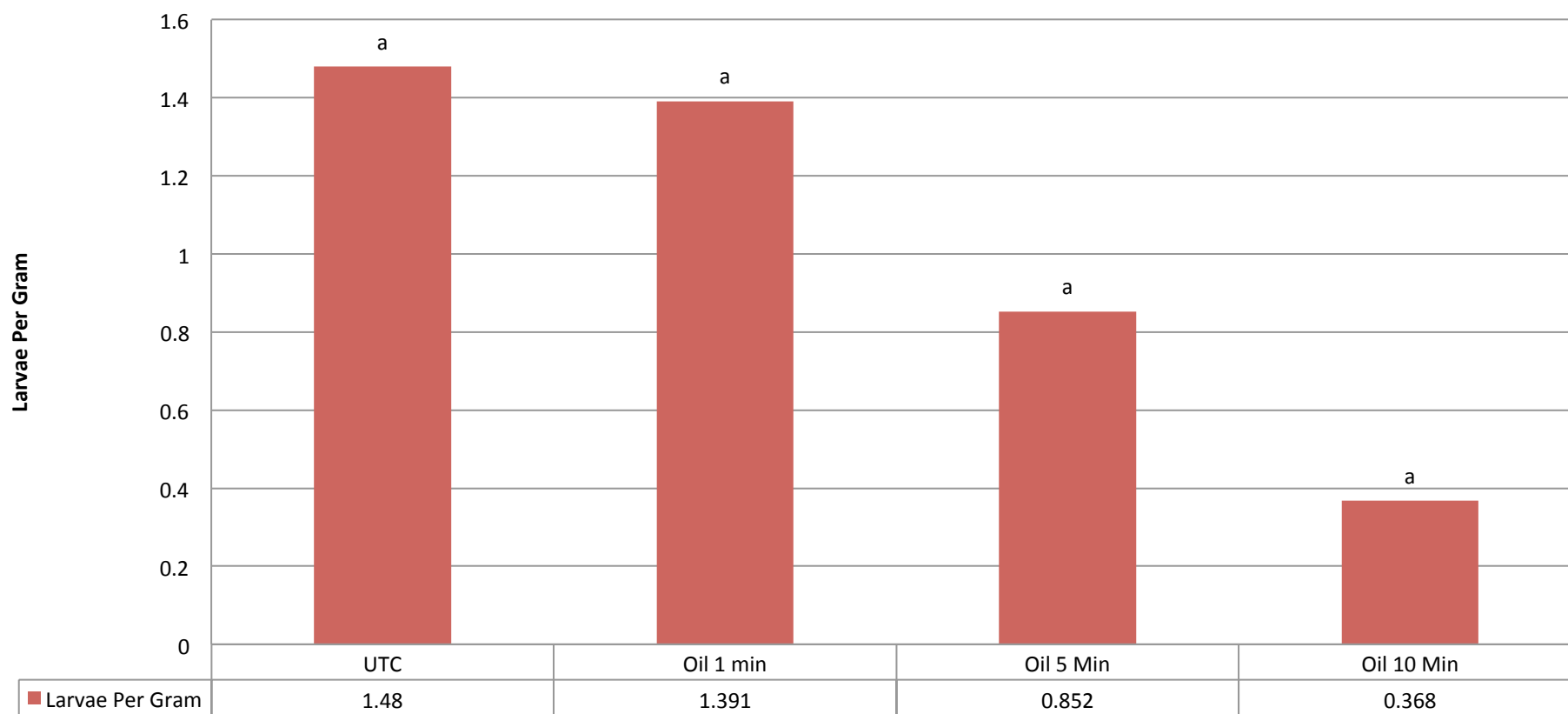
Post Harvest Study: Control of SWD In Raspberry After Harvest

Evaluating Low Temperature of Raspberry on SWD Larva Survival



Post Harvest Study: Control of SWD In Raspberry After Harvest

Evaluating 1% Oil Immersion of Raspberry on SWD Larva Survival



Post Harvest Study: Control of SWD In Raspberry After Harvest

Conclusions:

- Larval survival in fruit is temperature dependent.
- Low temperature had significant impact on larval survivability in raspberry
- Temperatures at 34F for 72 hours showed significant impact on larval survivors.
- SWD damaged berries exposed to a immersion in 1% oil showed reduced survivors at 5 and 10 minutes.
- A 10 min. immersion in 1% oil at 34F & 38F for 72 hrs. provided 100% larval mortality.



Biological Control Primer: Microbe Entomopathogens and Commercial Formulation Studies

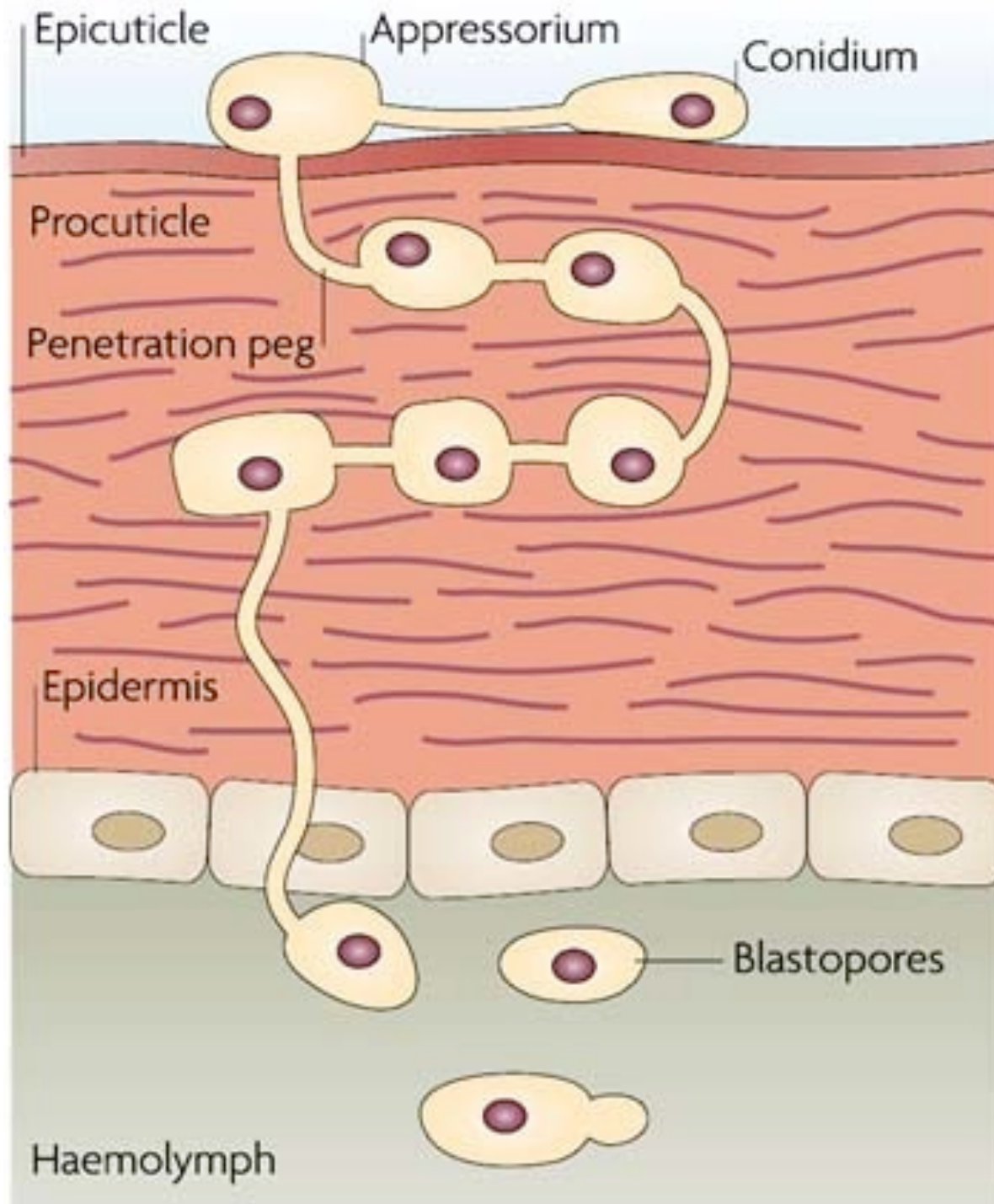


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Beauveria bassiana Basl.-Criv.
(Hypocreales; Clavicipitaceae)

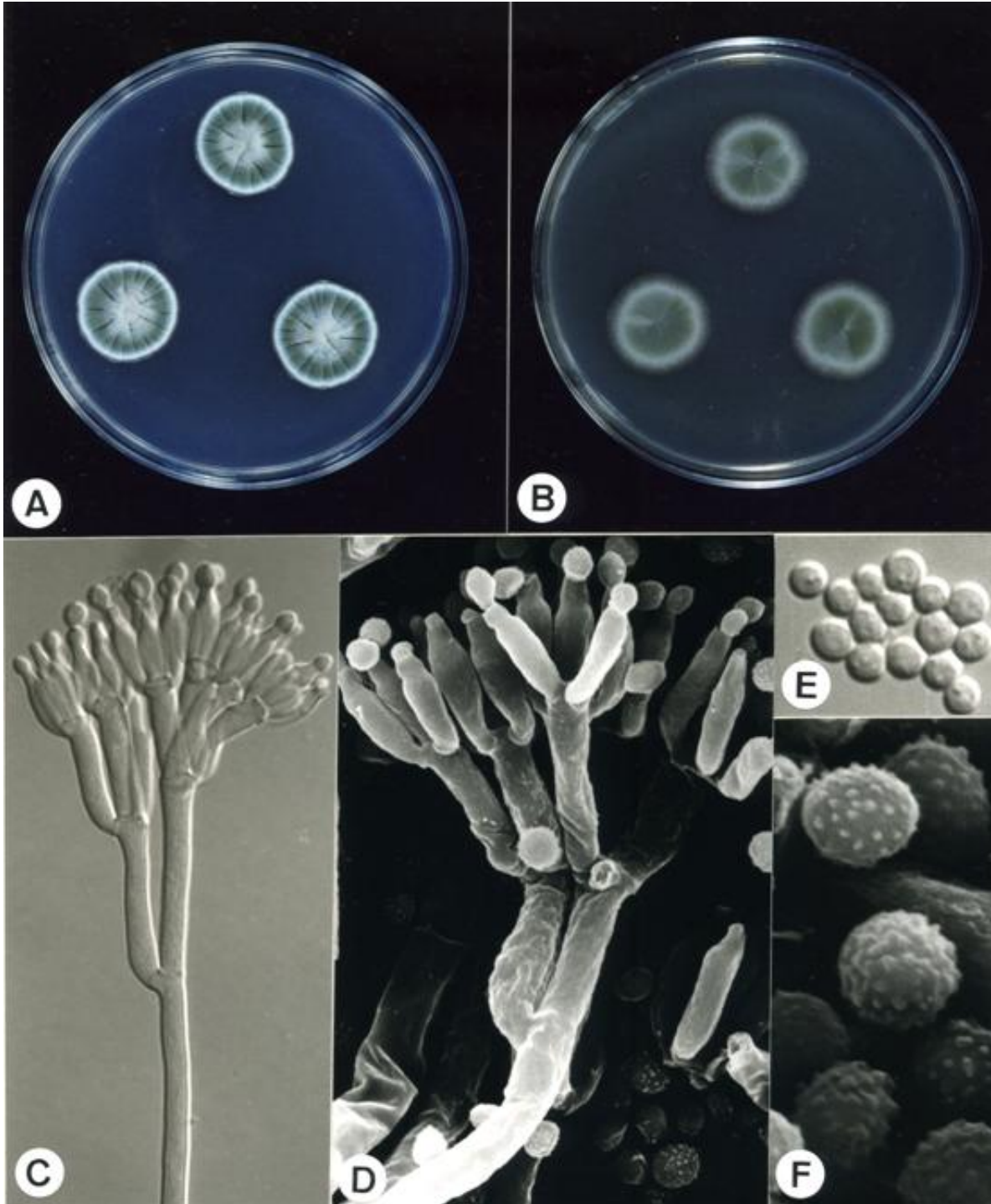
- Fungal parasite that causes White Muscardine Disease in insects.
- Microscopic spores of fungi come into contact with insect host, which germinate and penetrate the cuticle.
- Fungus then grows inside of insect, killing it within a matter of days.
- White fruiting bodies emerge from insect, releasing spores.
- Anamorph of *Cordyceps bassiana*.



The in vivo development cycle of the entomopathogenic fungi *Beauveria bassiana*

- Conidia (spores) adhere to the host cuticle, then the conidia germinate and the germ tube and appressorium (penetration structure) are produced.
- The cuticle is penetrated by a combination of mechanical pressure and the action of cuticle-degrading enzymes.
- **The fungus grows by vegetative growth in the host haemocoel and external conidia are produced upon the death of the host**

Can fungal biopesticides control malaria?
 Matthew B. Thomas & Andrew F. Read
 Nature Reviews Microbiology 5, 377-383
 (May 2007)



Plates of *B. bassiana*

A. Dorsal surface

B. Ventral surface

C. Fruiting structures

D. Fruiting structures

E. Conidia

Objectives:

- Determine the lethality of *B. bassiana* on **SWD adults, larvae, and pupae.**
- Determine the effect of *B. bassiana* on **oviposition.**
- Determine if transfer between gravid **females and offspring** occurs, and if so, does it affect the next generation's size?
- Determine if generalized **strain** (GHA) performs as well as Diptera-specific strain (HF23 - BalEnce).



Methods and Materials (con't)

- Insects were **reared** in test tubes with 1 Tbs *Drosophila* media, 1.5 Tbs Distilled Water, and 0.5 tsp Active Dry Yeast at 23° C for up to 14 days.
- F2 Adults were removed for experimentation at or before 24 hours of pupal eclosion. **Healthy adults were selected** at random for experimentation after removal from colonies.
- **Washed and dried blueberries were sprayed** at highest labeled rates (Mycotrol O=2 qt/A, BalEnce=1 qt/A). Using airbrush at 20 psi air pressure, sprayed until point of drip on surface of fruit.
- Berries **allowed 2 hours to dry** under fume hood (reentry interval of both materials).
- 25 random male SWD and 25 random females SWD removed from colony and introduced to berries (**50 flies/treatment/rep.**).



Methods and Materials (con't)

- At 48 hours, insects removed and **eggs were counted**. Live insects were counted and placed in isolation. **All dead insects separated into isolation to observe potential fungal growth.**
- **Isolation chambers** kept at 23° C and 100% humidity to encourage visible fungal growth.
- **After 10 days, insects examined for *B. bassiana*, positive ID's attained through spore microscopy.**

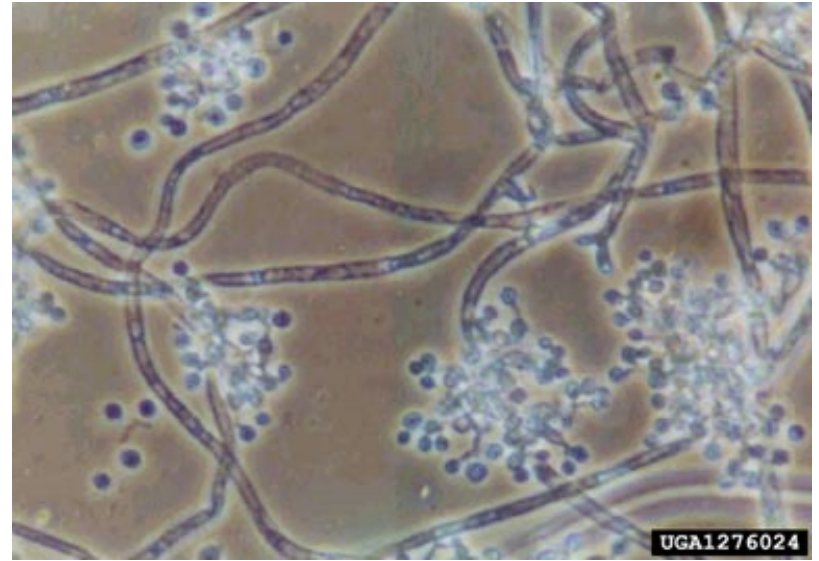


Photo: Svetlana Y. Gouli, University of Vermont, Bugwood.org



Mycotrol-O mycopesticide. (*Beauveria bassiana*) to control *D. suzukii* adults



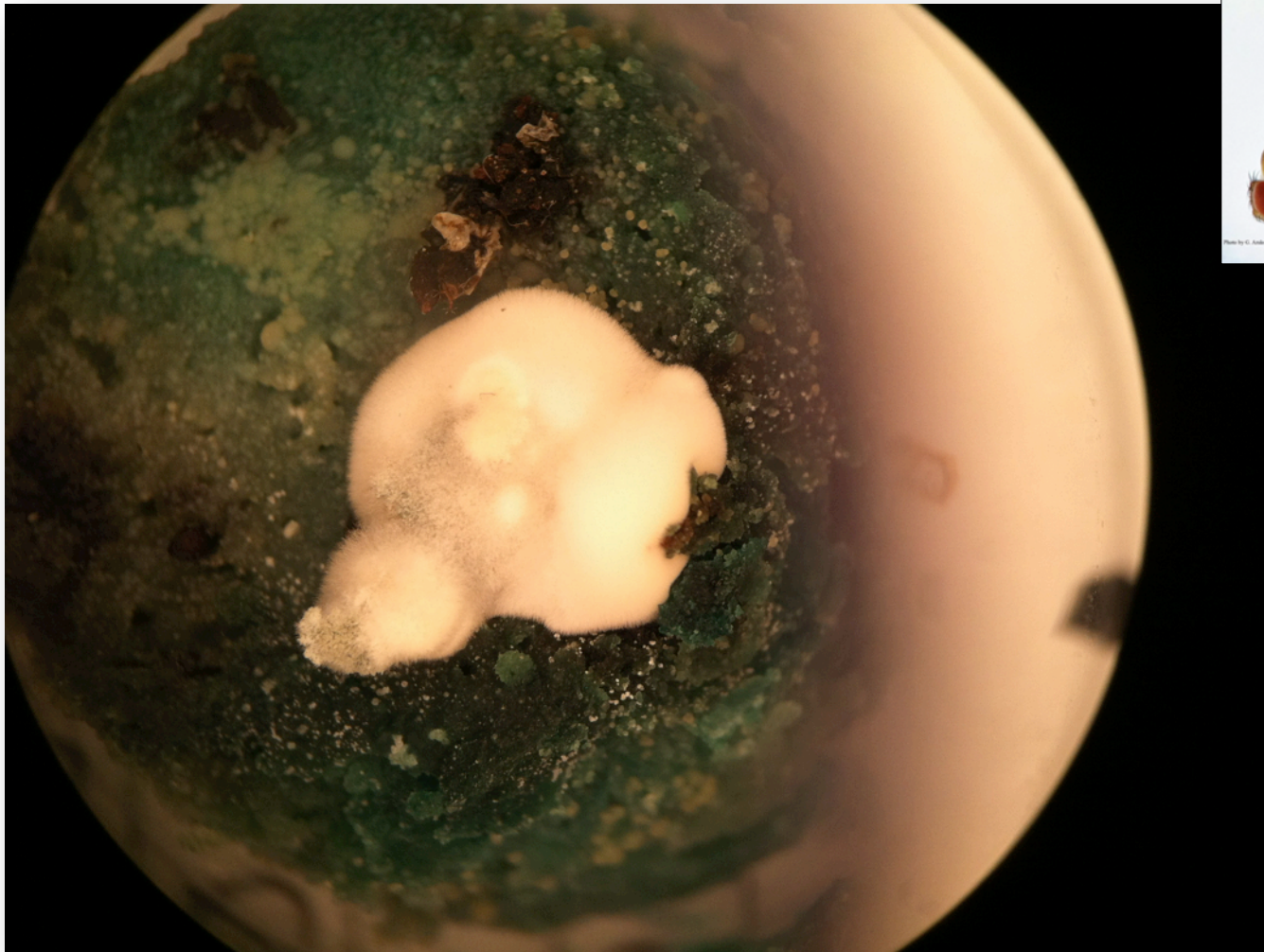
Advanced stage of fungal growth (~10 days of exposure).
Most of the spores have already detached.

Mycotrol-O mycopesticide. (*Beauveria bassiana*) to control *D. suzukii* adults

Recently deceased SWD adult (~5 days of exposure). Signs of fungal growth present on head (around antennae) and abdomen.



(Beauveria bassiana) Infesting *D. sukuzii* larvae

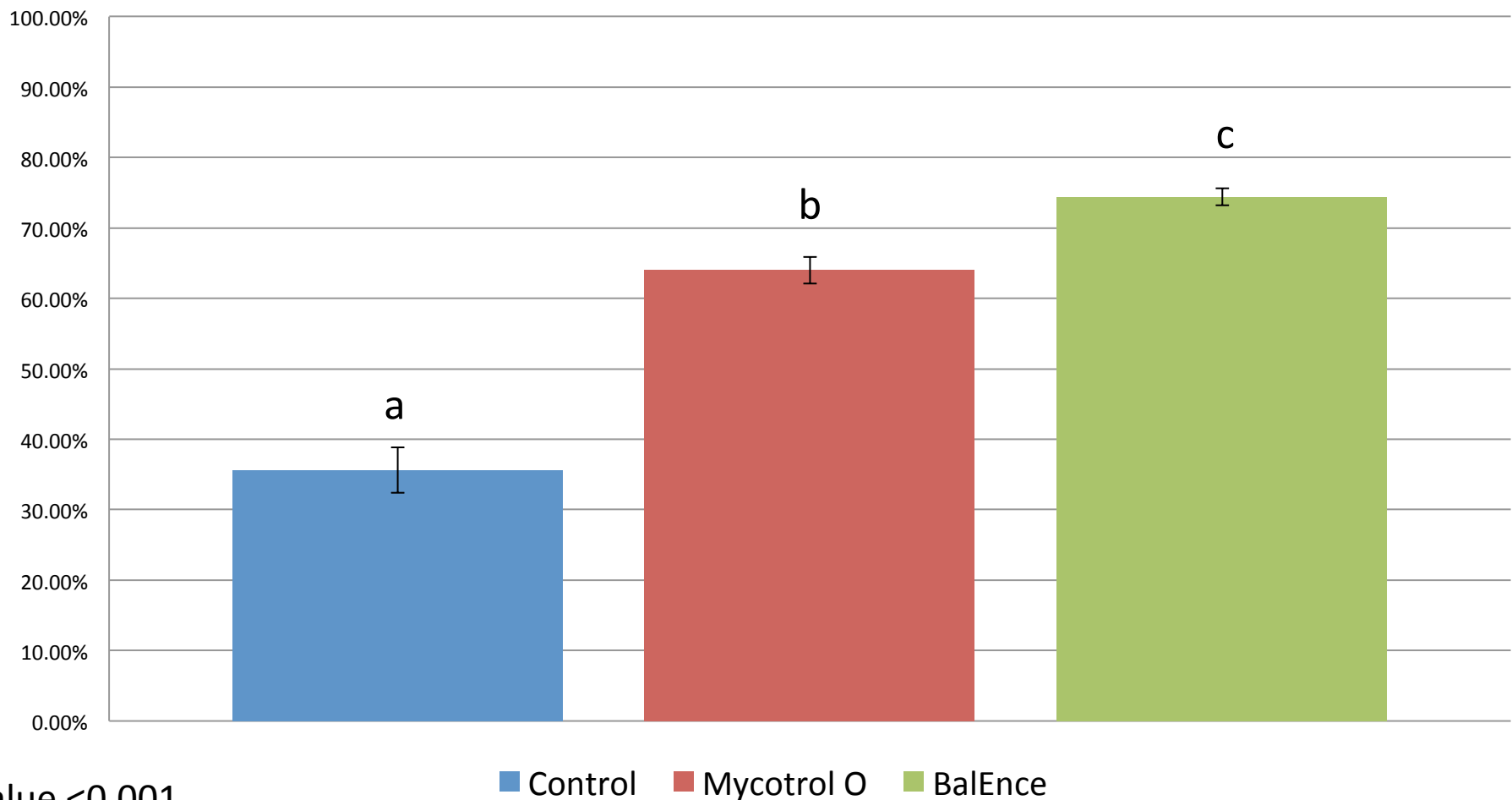


Advanced stage of fungal growth (~10 days of exposure) completely engulfing a cluster of 3rd instar Larvae.

Beauveria bassiana to manage *D. suzukii* larvae

Results: Significant increase in **mortality of adults on treated berries** compared to untreated check. BalEnce provided higher mortality when compared to Mycotrol O.

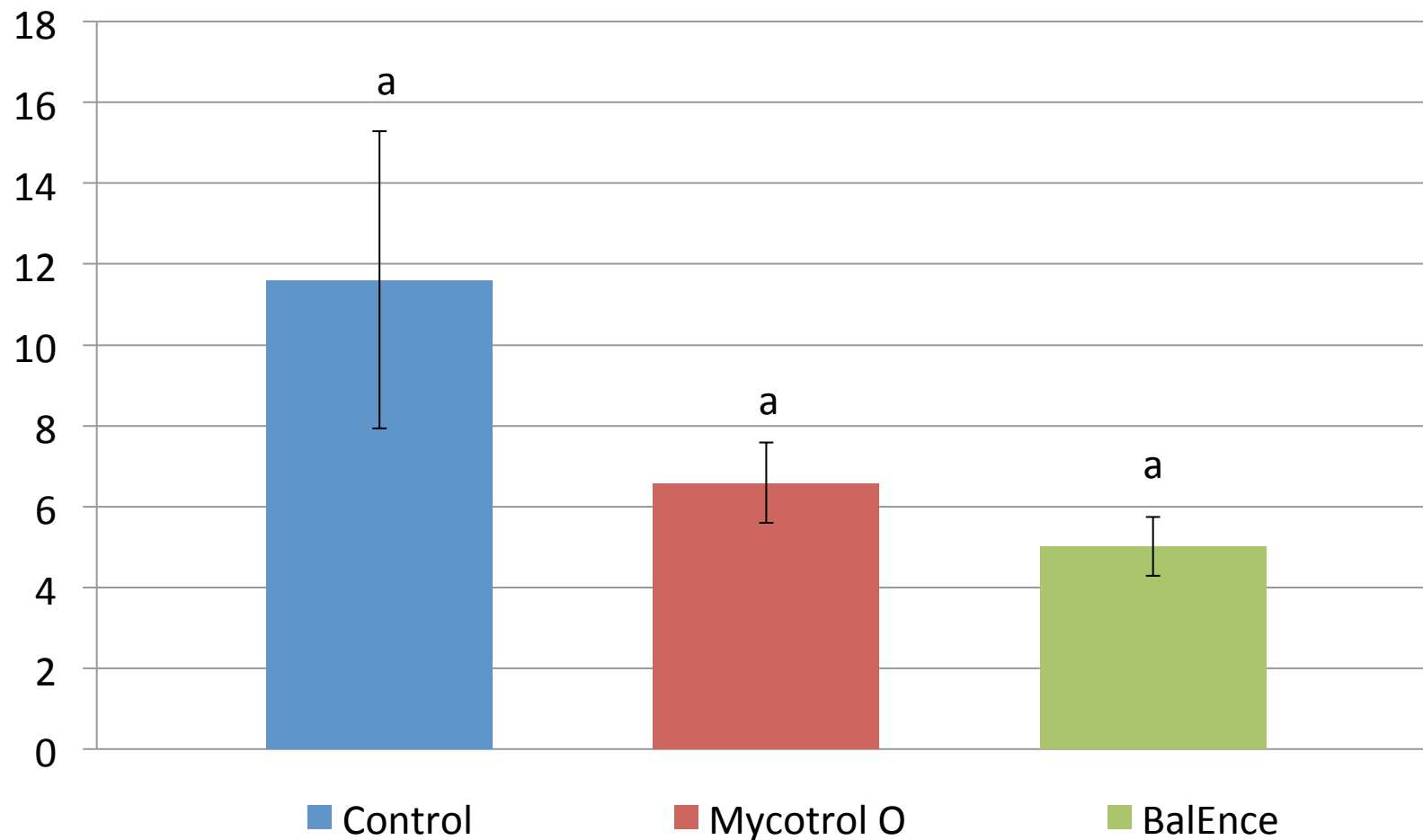
% Insects Mortality after 48 Hours



Beauveria bassiana to manage *D. suzukii* larvae

Results: Numeric decrease in ovipositional activity (NS).

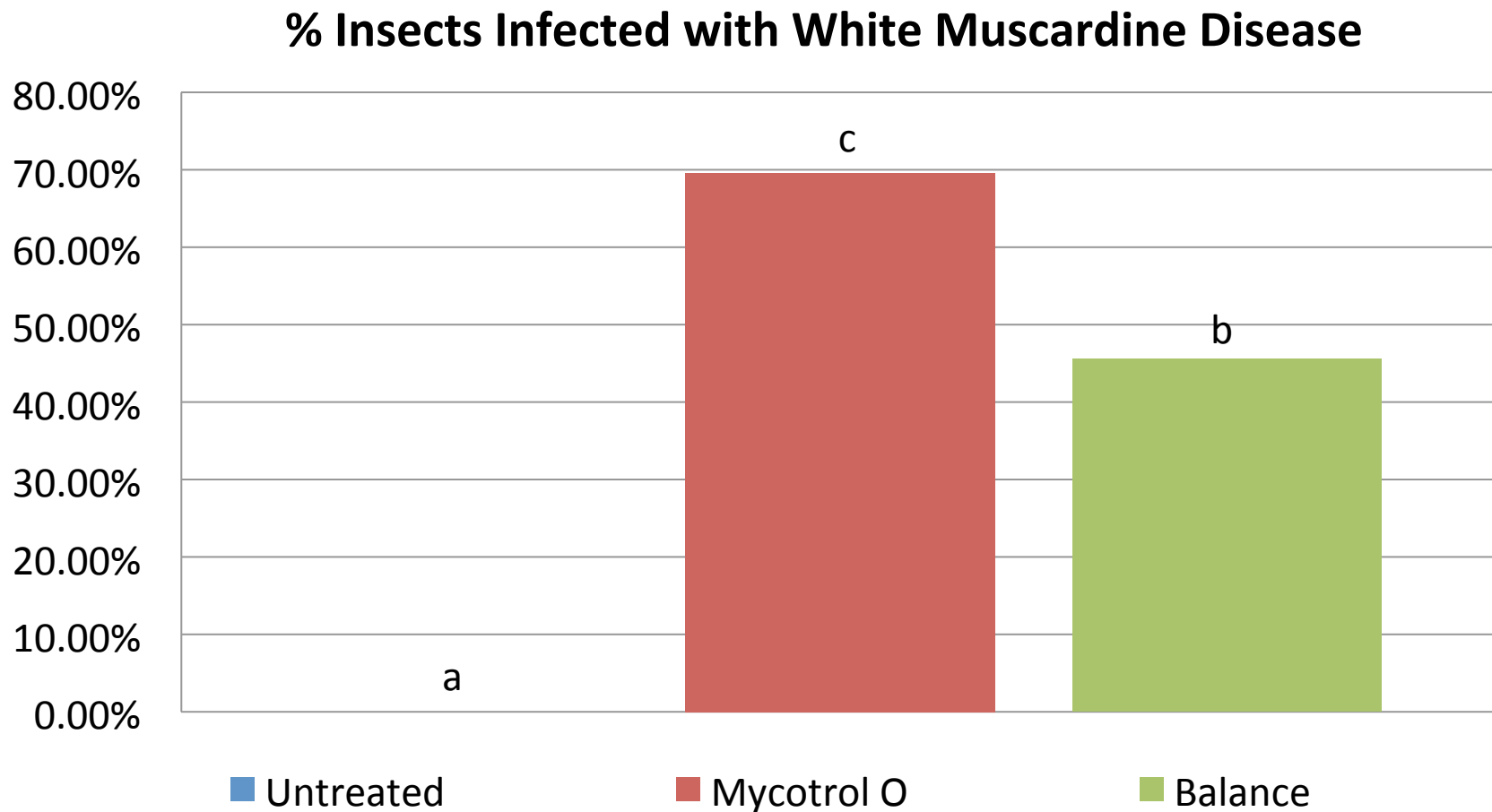
Eggs per gram after 48 Hours of SWD Adult Exposure



P Value 0.1687

***Beauveria bassiana* to manage *D. suzukii* larvae**

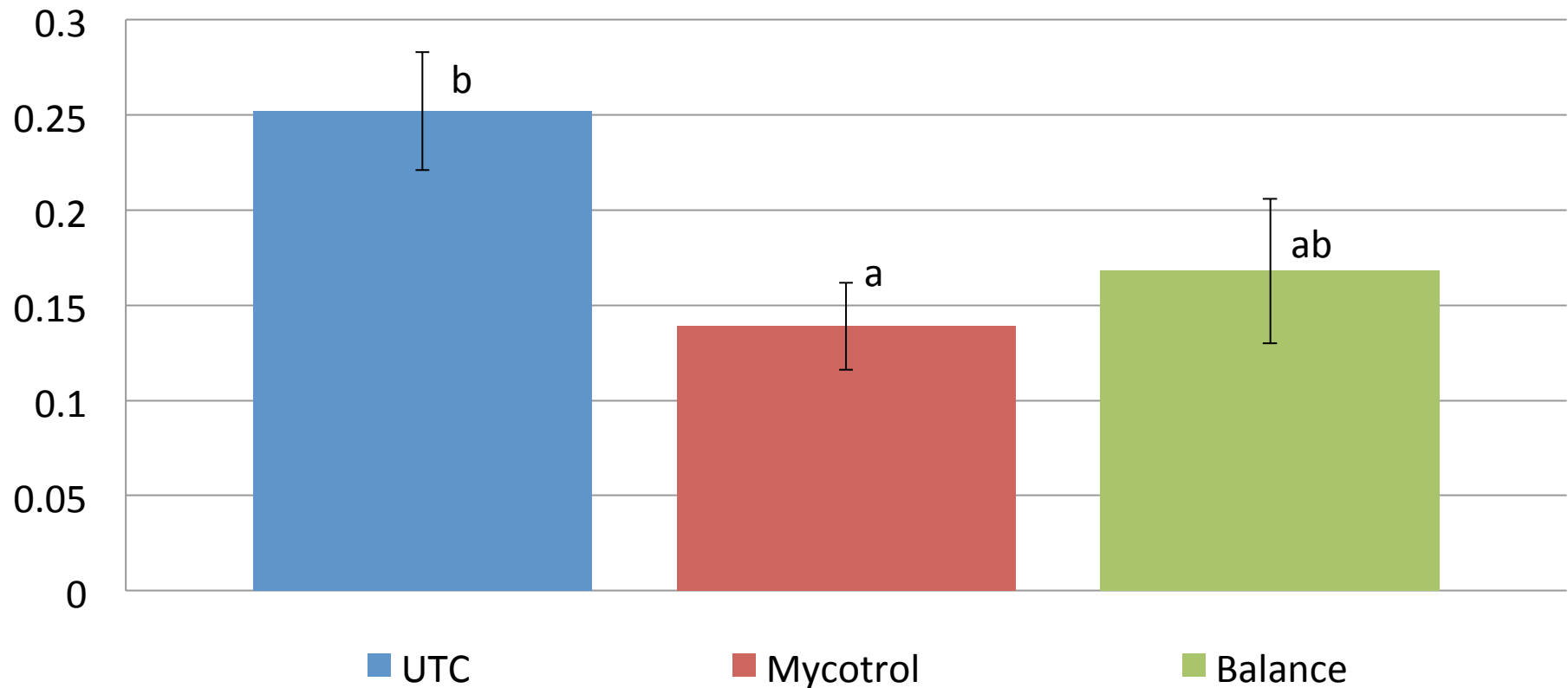
Results: SWD larva exposed to *B. bassiana* developed disease significantly more than untreated check. Mycotrol O appeared more virulent.



Beauveria bassiana to manage *D. suzukii* larvae

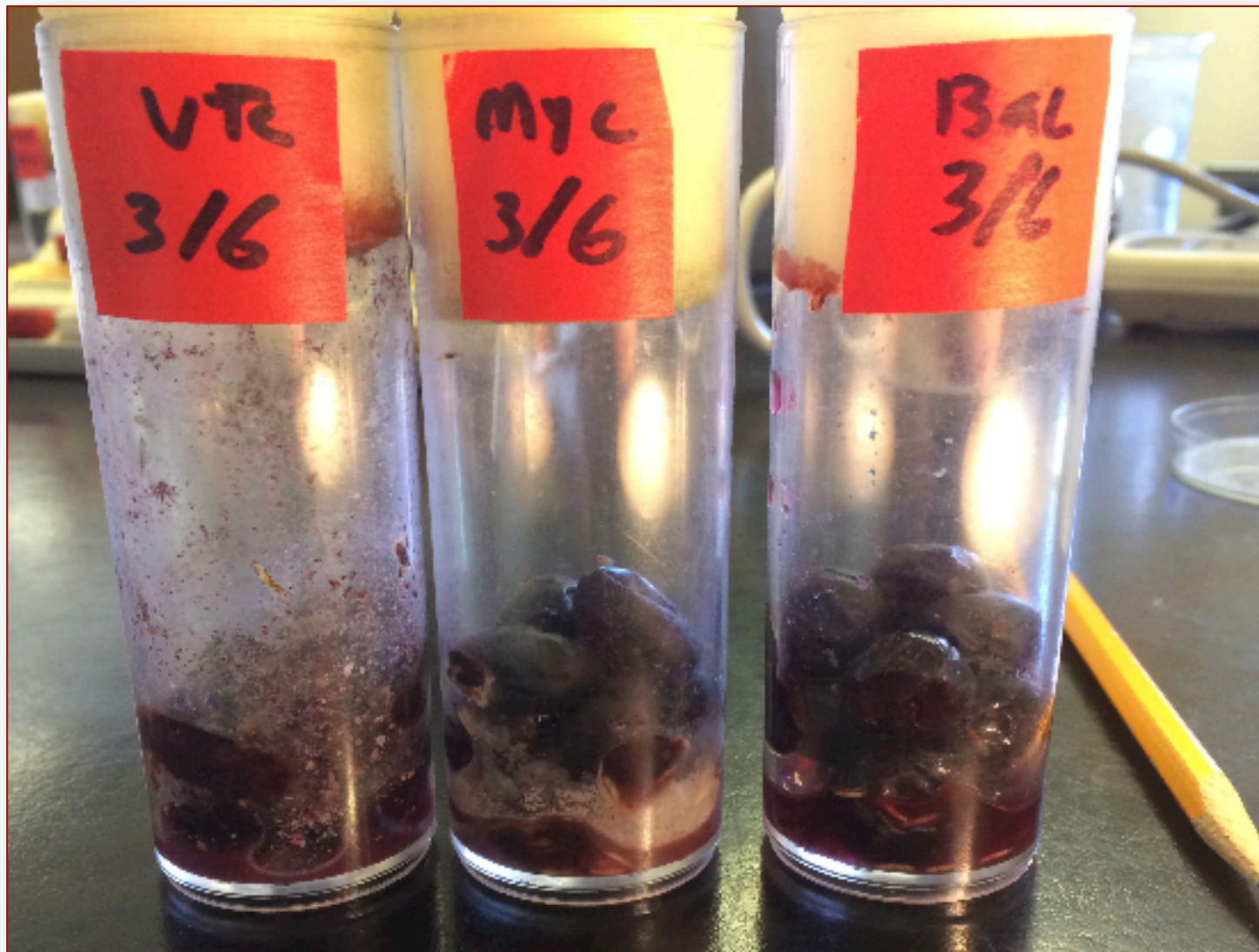
Results: Eggs laid in berries exposed to *B. bassiana* were somewhat less likely to mature to adulthood than those laid in untreated berries

Egg Survival (14 Days post Spray)



Data transformed prior to ANOVA from percentages. P Value: 0.07

Breakdown of Untreated (UTC) Fruit at 14 d.
relative to *B. bassiana* treated fruit



Conclusions

- Both *B. bassiana* formulations cause mortality within 48hrs.
.
- Neither formulation works quickly enough to decrease egg-laying significantly.
- Insects exposed to Mycotrol O appear to express mature *B. bassiana* more readily than those exposed to BalEnce.
- Eggs that are laid on *B. bassiana* exposed berries are less likely to mature.

African Fig Fly, *Zaprionus indianus* Gupta



African Fig Fly, *Zaprionus indianus* Gupta



- **Introduction:** The fig fruit fly is native to tropical Africa, but has been found in South America, including Brazil in 1999 (Vilela 1999).
- Central Florida on 26 July, 2005, Virginia and Mississippi in 2012.
- In apple cider baited traps *Zaprionus indianus* Gupta were found in Milton, NY on 4 September, 2012 and August 2014.

African Fig Fly, *Zaprionus indianus* Gupta



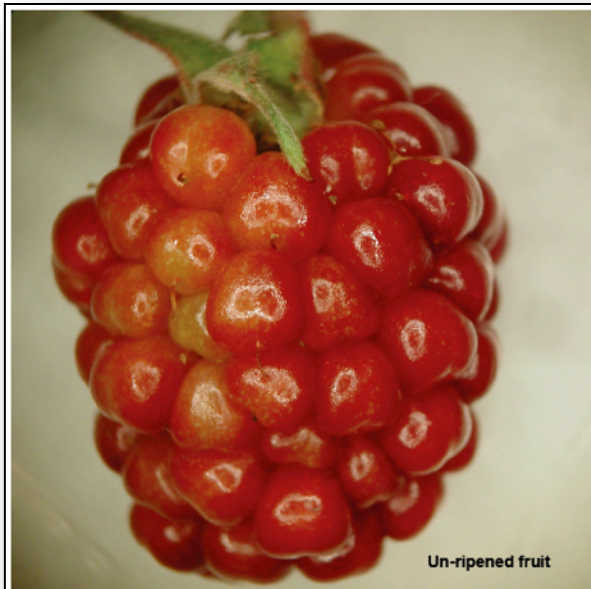
- **Description:** A striking pair of white stripes from the antennae, dorsally along distinctive red eyes to the end of the thorax with two black lines bordering each white stripe.
- The body is yellow in color approximately 3.5 mm in length
- Development time is approximately 19 days from egg to adult.
- The African fig fruit fly are capable of producing numerous generations in a season.

African Fig Fly: Crops at Risk



- **Damage: Predominately to citrus and grape**
- **Hudson Valley:**
 - **4 AFF in 2012**
 - **0 AFF in 2013**
 - **3 AFF in 2014**
- **Reports from Rutgers, NJ of wine grape injury independent of SWD injury.**
- **Not yet a threat in NY**

Managing Insecticide Resistance: Program Rotation Considerations



Peter Jentsch
Senior Extension Associate – Entomology



Cornell University
College of Agriculture and Life Sciences

Hudson Valley Research Laboratory

Thank You



Technical staff and assistants



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Managing Insecticide Resistance: Program Rotation Considerations

- Potential for SWD to Develop Resistance to Insecticides
- Classes of NYS Labeled Insecticides for SWD
- Rotation of Insecticide Classes: Examples



Managing Insecticide Resistance: Program Rotation Considerations

Insecticide Resistance or **Pesticide resistance** is a decrease in susceptibility of a pest population to a pesticide that was previously effective at controlling the pest.

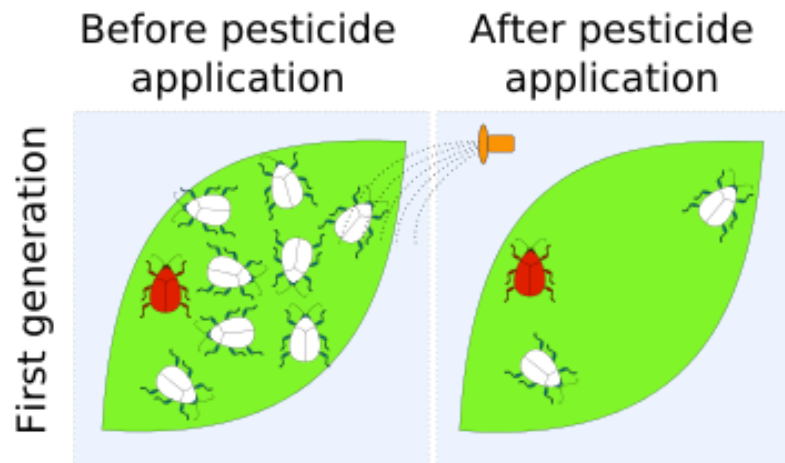
The failure of a product to perform in a real situation, referred to as **field resistance**. Resistance occurs through **natural selection**: resistant organisms survive and pass on their genetic traits to their offspring.



Managing Insecticide Resistance: Program Rotation Considerations

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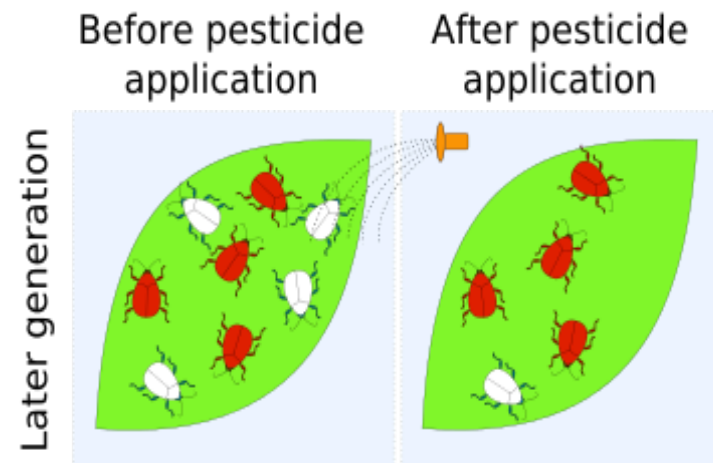
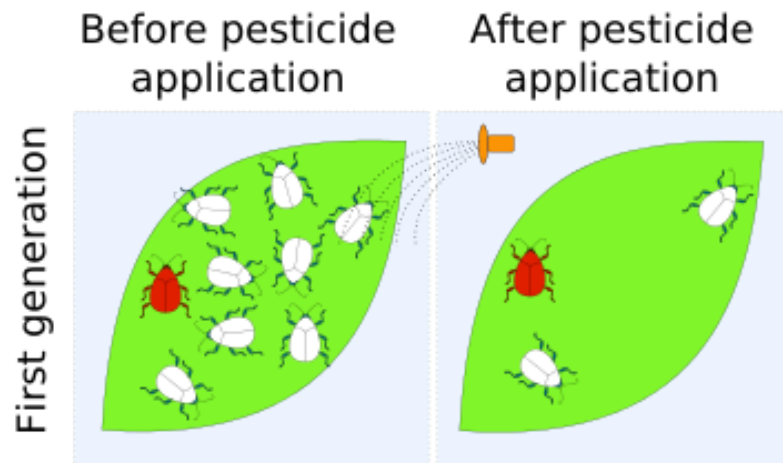
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Managing Insecticide Resistance: Program Rotation Considerations

Insecticide Resistance or **Pesticide resistance** is a decrease in susceptibility of a pest population to a pesticide that was previously effective at controlling the pest.

The failure of a product to perform in a real situation, referred to as **field resistance**. Resistance occurs through **natural selection**: resistant organisms survive and pass on their genetic traits to their offspring.



Factors Contributing to Insecticide Resistance

1. **Mutations** developed by insecticide use give rise to a change in the insect physiology, altering the target binding site.

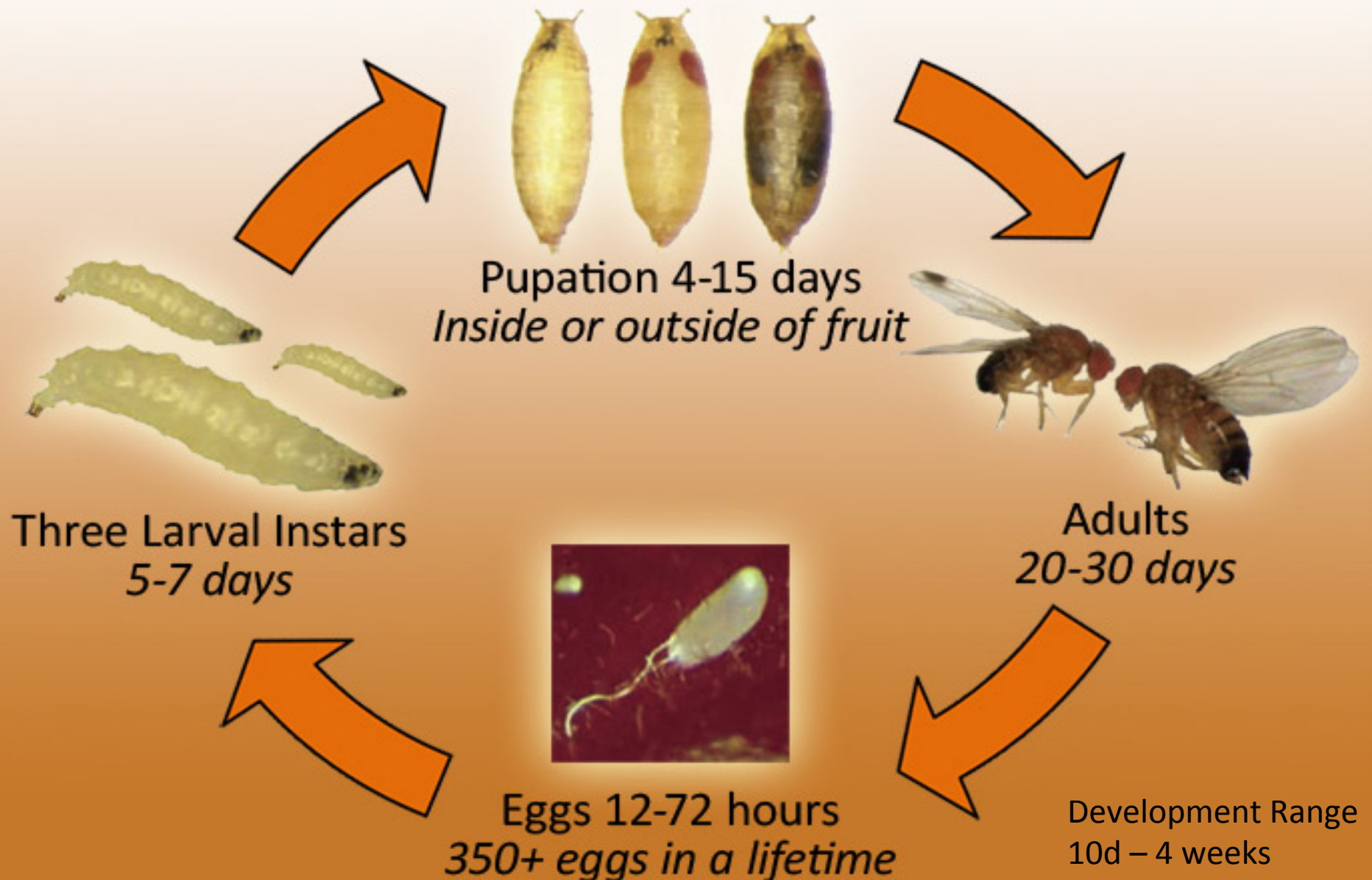
Insect species that are usually capable of **producing large number of offspring**, increases the probability of random mutations, increasing insecticide resistance.

2. The **speed with which a species develops** (generation time) and the **number of offspring** that are produced contribute to increasing the speed of resistance development.



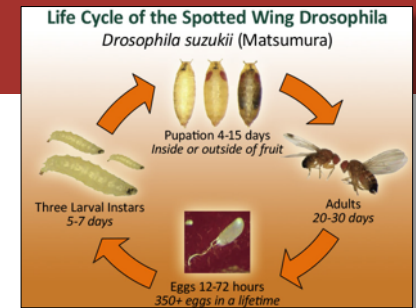
Life Cycle of the Spotted Wing Drosophila

Drosophila suzukii (Matsumura)



Factors Contributing to Insecticide Resistance

- Range of 3-10 generations in NY
- SWD has a very high probability of insecticide resistance development.



Managing Insecticide Resistance (IRM)



- How do we manage resistance??
- Resistance management programs challenging.
- Limitations for successful SWD IRM include:
 - Number of insecticide tools (too few)
 - Number of insecticide classes
 - Label restrictions
 - DTH, PHI, Apps./season, Total A.I. per season



Managing Insecticide Resistance



- **Blackberry and raspberry**, action threshold is 1st adult detection using a *3-4 day application interval program*.
- **Blueberry management** should begin within 7-21 days of 1st adult, action threshold is 1st egg detection using a *7-day application interval program*.
- **IRAC Class Rotation:** A single IRAC class of insecticide should be used for each generation; rotate to different class every 10d (Warm: summer) to 3-4 weeks (Cool: Spring & Fall).
- <http://www.irac-online.org/documents/moa-classification/?ext=pdf>



Managing Insecticide Resistance: www.fruit.cornell.edu/

RASPBERRIES & BLACKBERRIES										
PRODUCT	AI ¹	IRAC group	EPA#	RATE/A	REI ³	DTH ⁴	Max. Prod/A/yr (ai)	Total applic's	Spray Interval	Probable efficacy
[®] Entrust Naturalyte (2ec)	spinosad	5	62719-282	1.25-2 oz	4 hr	1 d	9 oz (0.45 lb)	3 per crop	6 d	Good to Excellent [#]
[®] Entrust SC (2ec)	spinosad	5	62719-621	4-6 fl oz	4 hr	1 d	29 fl oz (0.45 lb)	3 per crop	6 d	Good to Excellent [#]
[®] Delegate WG (2ec)	spinetoram	5	62719-541	3-6 oz	4 hr	1 d	19.5 oz (0.305 lb)	6	4 d	Excellent [#]
Brigade WSG (2ec)	bifenthrin	3A	279-3108	8.0-16 oz	12 hr	3 d	2 lb (0.2 lb)	1 post bloom	-	Excellent
Brigade EC (2ec)	bifenthrin	3A	279-3313	3.2-6.4 fl oz	12 hr	3 d	12.8 fl oz (0.2 lb)	1 post bloom	-	Excellent
Danitol 2.4EC	fenpropathrin	3A	59639-35	16 fl oz	24 hr	3 d	32 fl oz (0.6 lb)	2	-	Excellent
Mustang Max Insecticide (2ec)	zeta-cypermethrin	3A	279-3249	4 fl oz	12 hr	1 d	24 fl oz (0.15 lb)	6	7 d	Excellent
Triple Crown	bifenthrin, imidacloprid, zeta-cypermethrin	3A,4A	279-3440	6.4-10.3 fl oz	12 hr	3 d	10.3 fl oz (0.181 lb)	1 post bloom	7 d	Good to excellent
Malathion 5EC (2ec)	malathion	1B	19713-217	3.0 pts	12 hr	1 d	9 pts (6.0 lb)	3	7 d	Good
Malathion 5EC (2ec)	malathion	1B	66330-220	3.0 pts	12 hr	1 d	9 pts (6.0 lb)	3	7 d	Good
Malathion 8 Aquamul (2ec)	malathion	1B	34704-474	2.0 pts	12 hr	1 d	6 pts (6.0 lb)	3	7 d	Good
Malathion 57 (2ec)	malathion	1B	67760-40-53883	3.0 pts	12 hr	1 d	9 pts (6.0 lb)	3	7 d	Good
Assail 30SG	acetamiprid	4A	8033-36-70506	4.5-5.3 oz	12 hr	1 d	26.7 oz (0.5 lb)	5	7 d	Good [#]
[^] Pyganic EC 1.4	pyrethrin	3A	1021-1771	1 pt – 2 qts	12 hr	0 d	-	-	-	Fair to Poor
[^] Pyganic EC 5.0	pyrethrin	3A	1021-1772	4.5 – 18 fl oz	12 hr	0 d	-	-	-	Fair to Poor
[^] AzaSol	azadirachtin	UN	81899-4	6 oz in 50 gal	4 hr	0	-	-	-	Fair to Poor



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Managing Insecticide Resistance: www.fruit.cornell.edu/

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[®] Entrust SC (2ec)	spinosad	5	62719-621	4-6 fl oz	4 hr	1 d	29 fl oz (0.45 lb)	3 per crop	6 d	Good to Excellent [#]
[®] Delegate WG (2ec)	spinetoram	5	62719-541	3-6 oz	4 hr	1 d	19.5 oz (0.305 lb)	6	4 d	Excellent [#]
Brigade WSG (2ec)	bifenthrin	3A	279-3108	8.0-16 oz	12 hr	3 d	2 lb (0.2 lb)	1 post bloom	-	Excellent
Brigade EC (2ec)	bifenthrin	3A	279-3313	3.2-6.4 fl oz	12 hr	3 d	12.8 fl oz (0.2 lb)	1 post bloom	-	Excellent
Danitol 2.4EC	fenpropathrin	3A	59639-35	16 fl oz	24 hr	3 d	32 fl oz (0.6 lb)	2	-	Excellent
Mustang Max Insecticide (2ec)	zeta-cypermethrin	3A	279-3249	4 fl oz	12 hr	1 d	24 fl oz (0.15 lb)	6	7 d	Excellent
Triple Crown	bifenthrin, imidacloprid, zeta-cypermethrin	3A,4A	279-3440	6.4-10.3 fl oz	12 hr	3 d	10.3 fl oz (0.181 lb)	1 post bloom	7 d	Good to excellent
Malathion 5EC (2ec)	malathion	1B	19713-217	3.0 pts	12 hr	1 d	9 pts (6.0 lb)	3	7 d	Good
Malathion 5EC (2ec)	malathion	1B	66330-220	3.0 pts	12 hr	1 d	9 pts (6.0 lb)	3	7 d	Good
Malathion 8 Aquamul (2ec)	malathion	1B	34704-474	2.0 pts	12 hr	1 d	6 pts (6.0 lb)	3	7 d	Good
Malathion 57 (2ec)	malathion	1B	67760-40-53883	3.0 pts	12 hr	1 d	9 pts (6.0 lb)	3	7 d	Good
Assail 30SG	acetamiprid	4A	8033-36-70506	4.5-5.3 oz	12 hr	1 d	26.7 oz (0.5 lb)	5	7 d	Good [#]
[^] Pyganic EC 1.4	pyrethrin	3A	1021-1771	1 pt – 2 qts	12 hr	0 d	-	-	-	Fair to Poor
[^] Pyganic EC 5.0	pyrethrin	3A	1021-1772	4.5 – 18 fl oz	12 hr	0 d	-	-	-	Fair to Poor
[^] AzaSol	azadirachtin	UN	81899-4	6 oz in 50 gal	4 hr	0	-	-	-	Fair to Poor



Managing Insecticide Resistance: www.fruit.cornell.edu/

RASPBERRIES & BLACKBERRIES										
PRODUCT	AI ¹	IRAC group	EPA#	RATE/A	REI ³	DTH ⁴	Max. Prod/A/yr (ai)	Total applic's	Spray Interval	Probable efficacy
[®] Entrust Naturalyte (2ec)	spinosad	5	62719-282	1.25-2 oz	4 hr	1 d	9 oz (0.45 lb)	3 per crop	6 d	Good to Excellent [#]
[®] Entrust SC (2ec)	spinosad	5	62719-621	4-6 fl oz	4 hr	1 d	29 fl oz (0.45 lb)	3 per crop	6 d	Good to Excellent [#]
[®] Delegate WG (2ec)	spinetoram	5	62719-541	3-6 oz	4 hr	1 d	19.5 oz (0.305 lb)	6	4 d	Excellent [#]
Brigade WSG (2ec)	bifenthrin	3A	279-3108	8.0-16 oz	12 hr	3 d	2 lb (0.2 lb)	1 post bloom	-	Excellent
Brigade EC (2ec)	bifenthrin	3A	279-3313	3.2-6.4 fl oz	12 hr	3 d	12.8 fl oz (0.2 lb)	1 post bloom	-	Excellent
Danitol 2.4EC	fenpropathrin	3A	59639-35	16 fl oz	24 hr	3 d	32 fl oz (0.6 lb)	2	-	Excellent
Mustang Max Insecticide (2ec)	zeta-cypermethrin	3A	279-3249	4 fl oz	12 hr	1 d	24 fl oz (0.15 lb)	6	7 d	Excellent
Triple Crown	bifenthrin, imidacloprid, zeta-cypermethrin	3A,4A	279-3440	6.4-10.3 fl oz	12 hr	3 d	10.3 fl oz (0.181 lb)	1 post bloom	7 d	Good to excellent
Malathion 5EC (2ec)	malathion	1B	19713-217	3.0 pts	12 hr	1 d	9 pts (6.0 lb)	3	7 d	Good
Malathion 5EC (2ec)	malathion	1B	66330-220	3.0 pts	12 hr	1 d	9 pts (6.0 lb)	3	7 d	Good
Malathion 8 Aquamul (2ec)	malathion	1B	34704-474	2.0 pts	12 hr	1 d	6 pts (6.0 lb)	3	7 d	Good
Malathion 57 (2ec)	malathion	1B	67760-40-53883	3.0 pts	12 hr	1 d	9 pts (6.0 lb)	3	7 d	Good
Assail 30SG	acetamiprid	4A	8033-36-70506	4.5-5.3 oz	12 hr	1 d	26.7 oz (0.5 lb)	5	7 d	Good [#]
[^] Pyganic EC 1.4	pyrethrin	3A	1021-1771	1 pt – 2 qts	12 hr	0 d	-	-	-	Fair to Poor
[^] Pyganic EC 5.0	pyrethrin	3A	1021-1772	4.5 – 18 fl oz	12 hr	0 d	-	-	-	Fair to Poor
[^] AzaSol	azadirachtin	UN	81899-4	6 oz in 50 gal	4 hr	0	-	-	-	Fair to Poor



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[®] Entrust SC (2ec)	spinosad	5	62719-621	4-6 fl oz	4 hr	1 d	29 fl oz (0.45 lb)	3 per crop	6 d	Good to Excellent [#]
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Brigade EC (2ec)	bifenthrin	3A	279-3313	3.2-6.4 fl oz	12 hr	3 d	12.8 fl oz (0.2 lb)	1 post bloom	-	Excellent
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Mustang Max Insecticide (2ec)	zeta-cypermethrin	3A	279-3249	4 fl oz	12 hr	1 d	24 fl oz (0.15 lb)	6	7 d	Excellent
Triple Crown	bifenthrin, imidacloprid, zeta-cypermethrin	3A,4A	279-3440	6.4-10.3 fl oz	12 hr	3 d	10.3 fl oz (0.181 lb)	1 post bloom	7 d	Good to excellent
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Malathion 8 Aquamul (2ec)	malathion	1B	34704-474	2.0 pts	12 hr	1 d	6 pts (6.0 lb)	3	7 d	Good
Malathion 57 (2ec)	malathion	1B	67760-40-53883	3.0 pts	12 hr	1 d	9 pts (6.0 lb)	3	7 d	Good
Assail 30SG	acetamiprid	4A	8033-36-70506	4.5-5.3 oz	12 hr	1 d	26.7 oz (0.5 lb)	5	7 d	Good [#]
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Malathion 8 Aquamul (2ec)	malathion	1B	34704-474	2.0 pts	12 hr	1 d	6 pts (6.0 lb)	3	7 d	Good
Malathion 57 (2ec)	malathion	1B	67760-40-53883	3.0 pts	12 hr	1 d	9 pts (6.0 lb)	3	7 d	Good
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Cornell University
College of Agriculture and Life Sciences

Hudson Valley Research Laboratory

Managing Insecticide Resistance: Raspberry



Example of IRM conventional program: Mode of Action (MoA)

MoA-w – Pyrethroids: IRAC 3A

Baythroid XL, Brigade 2EC, Danitol, TripCr, Mustang Max (7d / 6 apps.)

MoA-x – Organophosphates: IRAC 1B

Malathion (7d / 3 apps.)

MoA-y – Spinetoram: IRAC 5

Entrust, Delegate (4d / 6apps.)

MoA-z – Neonicotinoids: IRAC 4A

Provado (Pre-mix), Assail (7d / 5apps.)

Managing Insecticide Resistance: Raspberry



Example of a IRM conventional program:

MoA-w – Pyrethroids: IRAC 3A

Baythroid XL, Brigade 2EC, Danitol, TripCr, Mustang Max (7d / 6 apps.)

MoA-x – Organophosphates: IRAC 1B

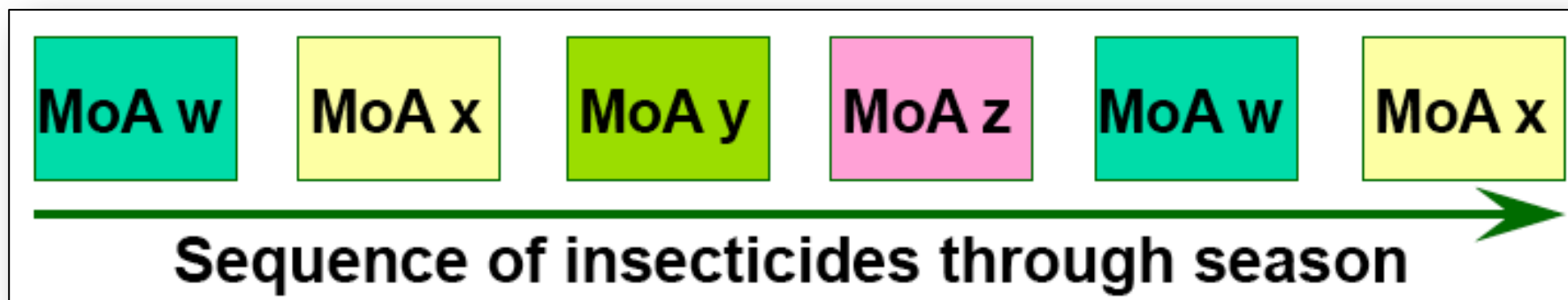
Malathion (7d / 3 apps.)

MoA-y – Spinetoram: IRAC 5

Delegate (4d / 6apps.)

MoA-z – Neonicotinoids: IRAC 4A

Provado (Pre-mix), Assail (7d / 5apps.)



Managing Insecticide Resistance: Raspberry



MoA-w – Pyrethroids: IRAC 3A

Baythroid XL, Brigade 2EC, Danitol, TripCr, Mustang Max (7d / 6 apps.)

MoA-x – Organophosphates: IRAC 1B

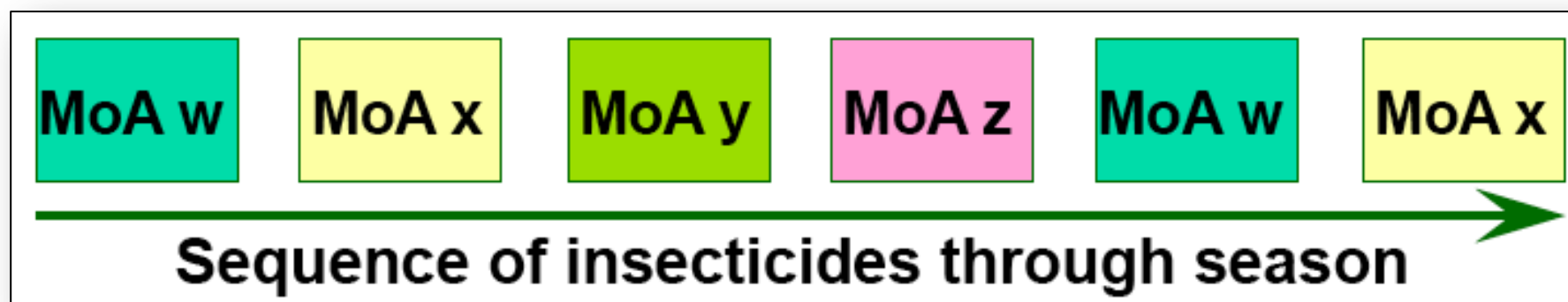
Malathion (7d / 3 apps.)

MoA-y – Spinetoram: IRAC 5

Delegate (4d / 6apps.)

MoA-z – Neonicotinoids: IRAC 4A

Provado (Pre-mix), Assail (7d / 5apps.)



J 10 15 19 23 27 30 A 3 7 11 15 19 23 27 S 1 5 9 13 17 21 25

Managing Insecticide Resistance: Raspberry



Using 'Alternate Row Middle' Applications to Optimize Use of Insecticide

Biologically based Spotted Wing Drosophila management

Hannah Burrack, Rufus Isaacs, Vaughn Walton

Nik Wiman, Samantha Tochen, Daniel Dalton, Betsey Miller, Jimmy Klick, Wei Yang, Denny Bruck, Jana Lee, Hannah Burrack, Claudio Ioriatti, Gianfranco Anfora, Alberto Grassi, Peter Shearer, Kent Daane, Xingeng Wang



MICHIGAN STATE UNIVERSITY

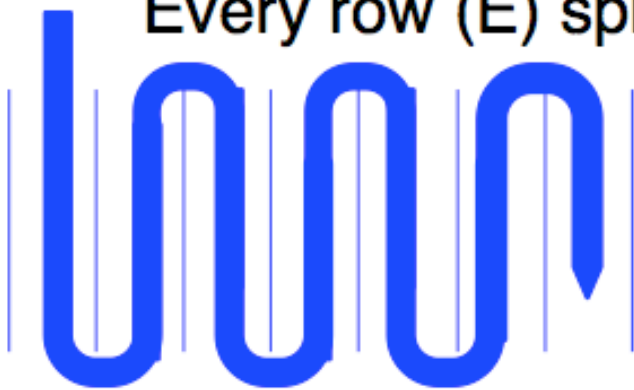


Managing Insecticide Resistance: Raspberry

Efficacy of **alternate row sprays** in raspberries



Every row (E) sprays



Alternate row (A) sprays



- A-sprays did not result in yield loss in low pressure years
- A-sprays reduced application time, chemical costs and area sprayed by 50%

Managing Insecticide Resistance: Raspberry



MoA-w – Pyrethroids: IRAC 3A

Baythroid XL, Brigade 2EC, Danitol, TripCr, Mustang Max (7d / 6 apps.)

MoA-x – Organophosphates: IRAC 1B

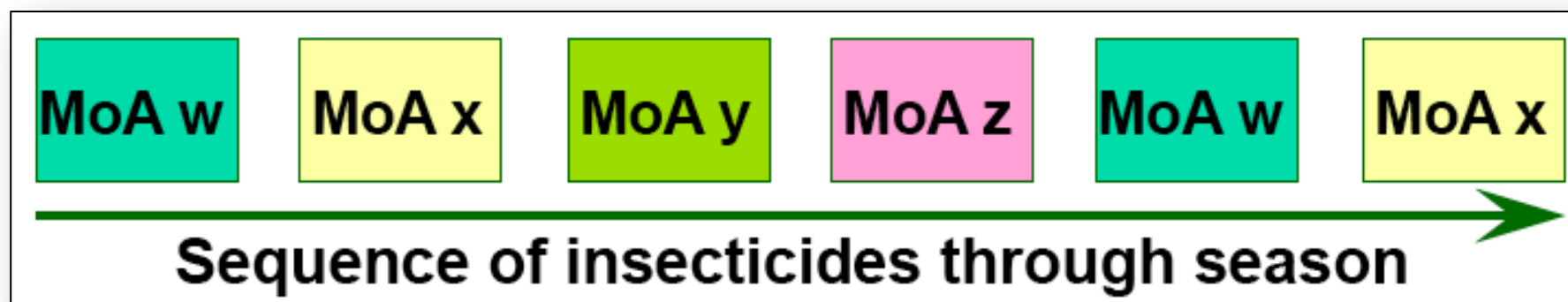
Malathion (7d / 3 apps.)

MoA-y – Spinetoram: IRAC 5

Delegate (4d / 6apps.)

MoA-z – Neonicotinoids: IRAC 4A

Provado (Pre-mix), Assail (7d / 5apps.)



J 10 15 19 23 27 30 A 3 7 11 15 19 23 27 S 1 5 9 13 17 21 25