Biological Insecticides:
What are they and do they really work ?

THE CONNECTICUT POMOLOGICAL SOCIETY
Annual Meeting - November 27, 2018
Middletown Elks Lodge 44 Maynard St, Middletown, CT

Cornell University
Hudson Valley Research Laboratory

THE JENTSCH LAB

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

WELCOME ENTOMOLOGY BROWN MARMORATED STINK BUG INVASIVES ORGANIC AG. RESEARCH TREE FRUIT THE HEIRLOOM ORCHARD
VEGETABLE SWEET CORN SMALL FRUIT GRAPE IN THE NEWS

INSECTICIDE AND ACARICIDE STUDIES


INSECTICIDE AND ACARICIDE STUDIES IN EASTERN NEW YORK

RESULTS OF INSECTICIDE AND ACARICIDE STUDIES
IN EASTERN NEW YORK;
Hudson Valley Laboratory,
Highland, NY

Insecticide screening is a critical component of pest management research. Results from these screens provide information to producers on how effective specific management programs work on key insect pests. It also provides options for timing and rates of newly developed modes of action on these insects, while demonstrating the negative impact these programs may have on important biological control agents such as predatory arthropods and a phytophagous mite response to both old and new formulations in these comparative studies.

Search

2017 BLOG PAGES

- The Heirloom Orchard: A Three-Day Series on Estate Orchard Management. Saturday Dec 8th, 15th, 22nd 2018. 5:00-8:00 pm HVRL 3357 Rt. 9W, Highland NY 12528
November 23, 2018
- BMSB Update: Stink Bug Feeding

Biological Insecticides

I. **Biological control organisms.**

II. **Biopesticides:** Microbial organisms such as bacteria, fungi, viruses, protozoa, or oomycetes or the toxins produced by organisms, laboratory reared and manufactured.

III. **Plant-Incorporated Protectants (PIPs)**: chemicals produced by plants after genetic modification (GMO or through breeding) to produce compounds resistant to insect or disease pests. Genes alter the manufacture of proteins increase plant defense mechanisms to improve resistance to pests. Ex. Bt Corn and Round-up Ready Corn

IV. **Natural products** such as hort-oils, fatty acids or soaps, repellents

V. **Attractants**: synthetic or natural products to lure and trap pests.

VI. **Barrier Film:** Inert coating to reduce attractiveness of host plant

Biological Insecticides

I. Biological control organisms:

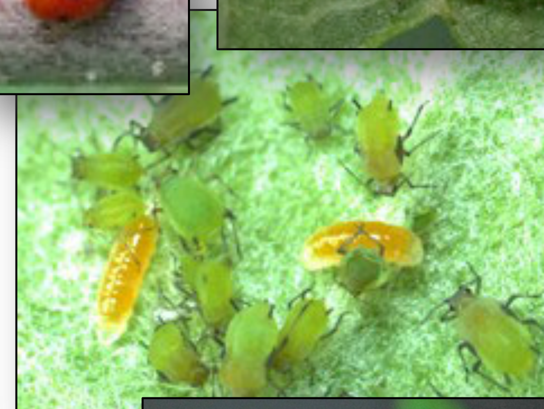
- **Predators:** feed directly on host pest life stages egg, larva, nymph and adult
- Predators are immature or adult forms
- Use host finding chemical cues ‘footprints’ such as host pheromones, plant host of pest, visual - color, sounds
- Predatory populations rise and fall based on prey populations, environmental conditions and agrochemical applications and residue

Biological Insecticides

I. Living organisms such as **biological control organisms**.
Predatory organisms of pests

a. Aphids

- Lacewing adults and larva
- Ladybird beetle adult and larva
- Cecidomyiidae larve (fly − gall midge)
- Syrphid larva (fly)



b. European Red Mite

- Phytoseiid Mite
  T. pyri, A. fallacius
- Stigmaid Mite
  Z. mali

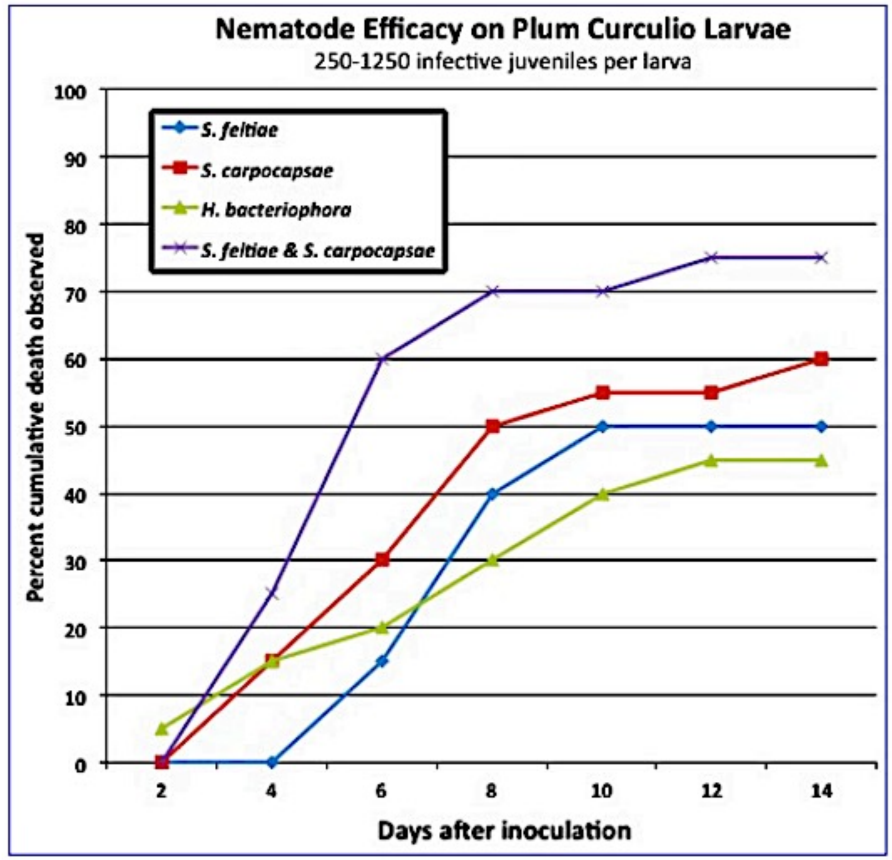
Do They work: YES
Insecticides (Pyrethroids) and fungicides (Manzate) significantly reduce predatory beneficials.
'Soft' programs and reduced rates of pesticides allow for higher field populations of predators

Biological Insecticides

I. Living organisms such as **biological control organisms**.
Predatory organisms of pests

c. Nematodes: 'Persistent' complex for managing plum curculio the Northeast

- Steinernema feltiae, S. Carpocapsa
  Heterorhabditis bacteriophora



Elson Shields, Art Agnello NYFQ Spring 2014

Applied to the soil. Use a CO_2 gradient to detect and infest White grub larva

Reduces oplum curculio larva in orchard floor
Do not impact migrating PC adults
Best use in organic orchards

Biological Insecticides

I. Living organisms such as **biological control organisms**.
Predatory organisms of pests

Aphids can build near apple harvest with fall rains and new growth.

Multicolored Asian Ladybird Beetle will also increase and feed on aphid, yet may begin to pupate on fruit, causing fruit injury.

Biological Insecticides

I. Biological control organisms:

- **Parasitoids:** (Hymenopteran − wasps) lay their eggs in pest life stages including egg, larva, nymph
- Parasitoids are adult forms. Immature develop within host.
- Use host finding chemical cues ‘footprints’ such as host pheromones, plant host of pest, visual - color, sounds
- Parasitoid populations often have multiple hosts, ‘follow’ prey populations as they , environmental conditions and agrochemical applications and residue
- Many reside outside of the Ag. crop

Biological Insecticides

Samurai wasp,
Trissolcus japonicus

I. Living organisms such as **biological control organisms**.

Parasitic organisms of pests (parasitoids)

a. Micro hymenoptera

- Samurai wasp, Trissolcus japonicus

Wasps lay their eggs into the eggs of a pest such as a stink bug
Wasp larva feed on developing stink bug nymph
Wasp adult emerges from egg

Do They work: YES. Pop. of BMSB held in check In Asia to significantly reduce crop injury.
Insecticide drift to stink bug habitat may reduce the parasitoid population

Biological Insecticides

II. **Biopesticides:** Infection from the organism and or toxins produced by organisms can develop; spores and toxins are laboratory reared and manufactured for use in pest management.

These include strains of **Viruses, Fungi and Bacteria.**

Products for use as insecticides come in many forms including spores, released toxins derived from fermentation processes and biproducts.

Insects exposed by viroid fragments, fungal spores or bacteria transmission through feces or direct contact will become infected, leading to a decline or mortality of the insect.

Biological Insecticides

II. **Biopesticides:** Viruses

Advantages in using microbial viruses

- Safety for humans and other nontarget organisms
- Reduction of pesticide residues
- Little or no development of resistance by the target organism
- No secondary pest outbreak and no preharvest interval is required
- Many are OMRI approved

Disadvantages

- Host specificity or narrow spectrum of a single species
- Long period of lethal infection is required
- Virus is inactivated by environmental factors like ultraviolet light, extreme temperature, etc.
- Often more expensive then conventional pesticides

Biological Insecticides

CYD-X®
INSECTICIDAL VIRUS
An Aqueous Suspension
Biological Insecticide for Control of the Codling Moth

II. Biopesticides: Virus

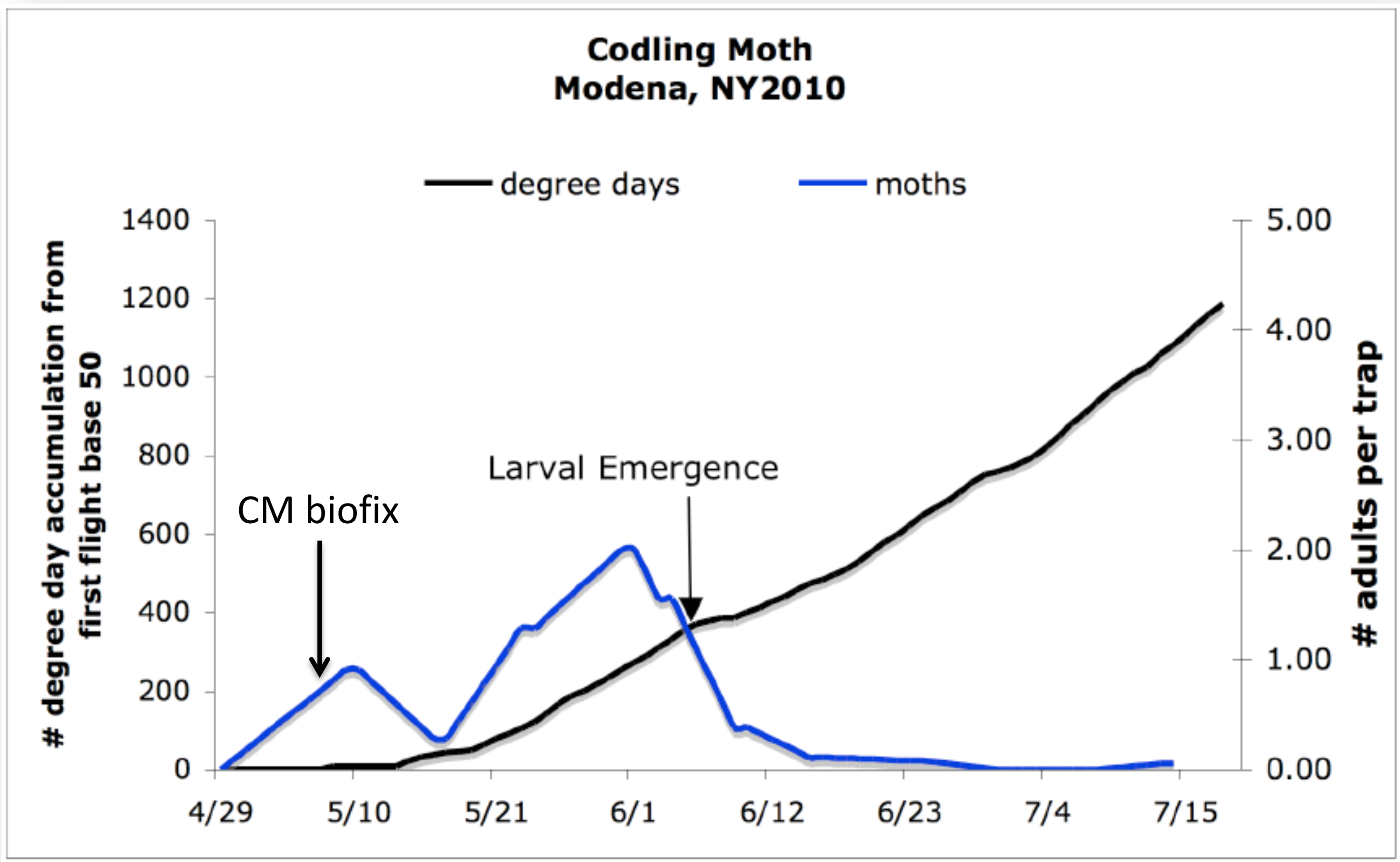
Viruses: Baculoviruses (BV) are parasitically replicating microscopic elements ingested by the insect establishing a systemic infection. Include nuclear polyhedrosis viruses (NPVs), granulosis viruses (GVs) and nonoccluded viruses.

Cyd-X, Virosoft, or Carpovirus are granulosis virus, is specific to codling moth (CM)

Very effective when applied in multiple applications of granulosis virus such as C, are best used at the onset of egg hatch, 220–250 DD in 5-7 day intervals until the end of hatch.

Biological Insecticides

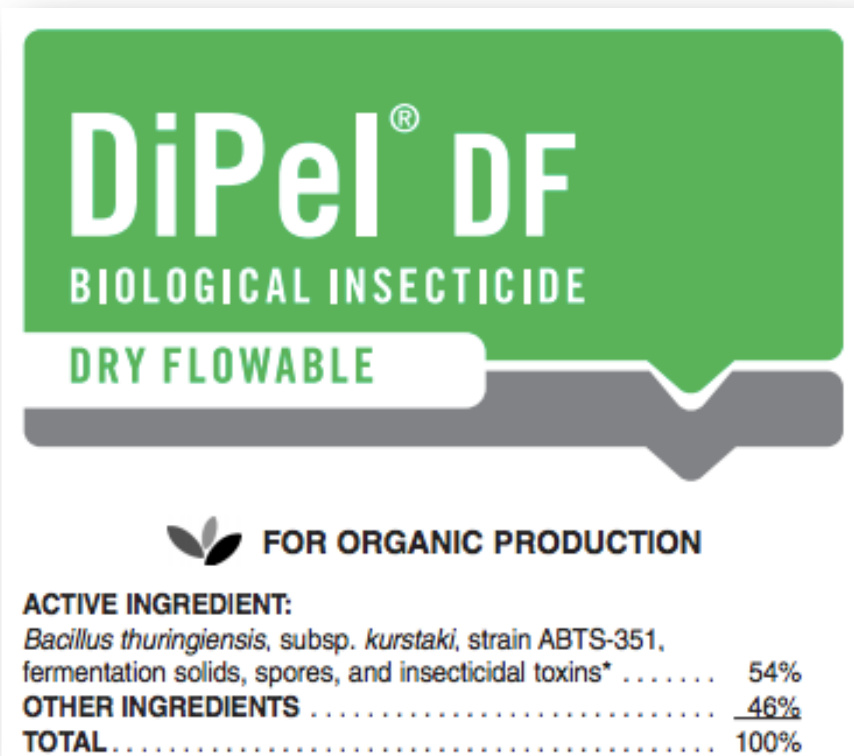
Granulosis virus when used with mating disruption (OFM / CM twin ties) applied at first trap capture of adult CM over successive years have found to be very effective



Biological Insecticides

II. Biopesticides: Toxins produced by organisms, laboratory reared and manufactured.

Bacteria: *Bacillus thuringiensis*/B.t. is a fermented toxin used at low rates using 5 day intervals is an excellent materials for OBLR, and can be used during bloom.



- Immature larval stages
- UV sensitive
  Best use during overcast sky
- Low rates using short
  re-application intervals
- Can be used during bloom
- Pollinator safe

Biological Insecticides

II. Biopesticides: Toxins produced by organisms, laboratory reared and manufactured.

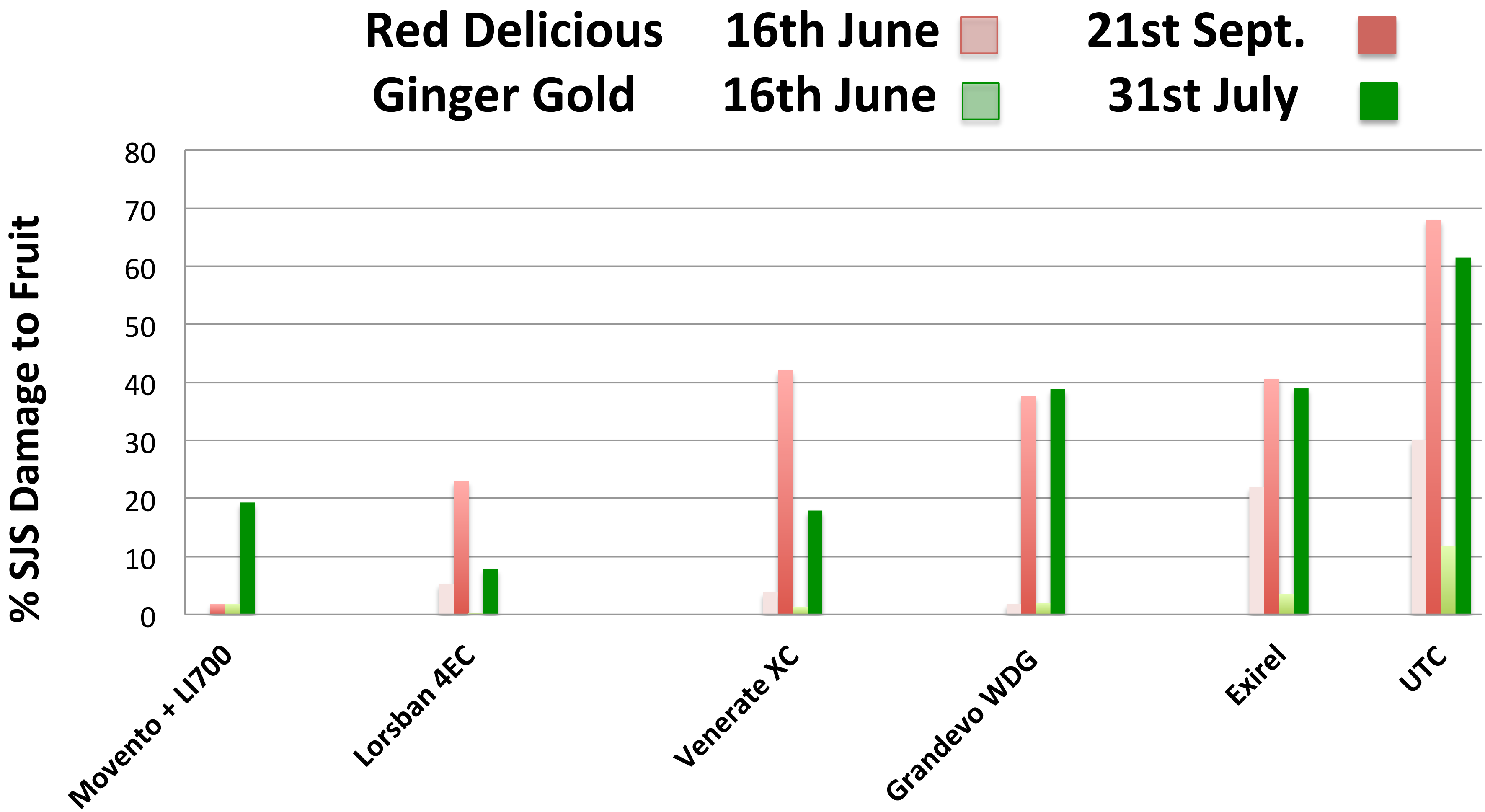
Bacteria: Venerate, *Burkholderia* spp. strain A396, a genus of Proteobacteria manufactured by Marrone Bioscience

Venerate acts as an anti-feedent against San Jose Scale (SJS) and Brown Marmorated Stink Bug (BMSB).

- Target the crawler stage of San Jose scale according to scouting using two applications at 7-day intervals, using minimum of 75 gal,.A to achieve full coverage of foliage and fruit.
- Use of a nonpenetrating spreader-sticker to improve coverage and rain fastness.

Marrone Bio Innovations

% San Jose Scale Fruit Injury
1st & 2nd Gen. HVRL, 2017



Spinosad

Spinosad is fermentation product, gram-positive bacterial species *Saccharopolyspora spinosa* in the actinomycetes bacteria group.

First isolated in 1985 from soil collected inside a non-operational sugar mill rum still in the Virgin Islands. Highly effective insecticide through ingestion and contact, very effective broad spectrum insecticide. Works well Lepidoptera larva and spotted wing drosophila (SWD)

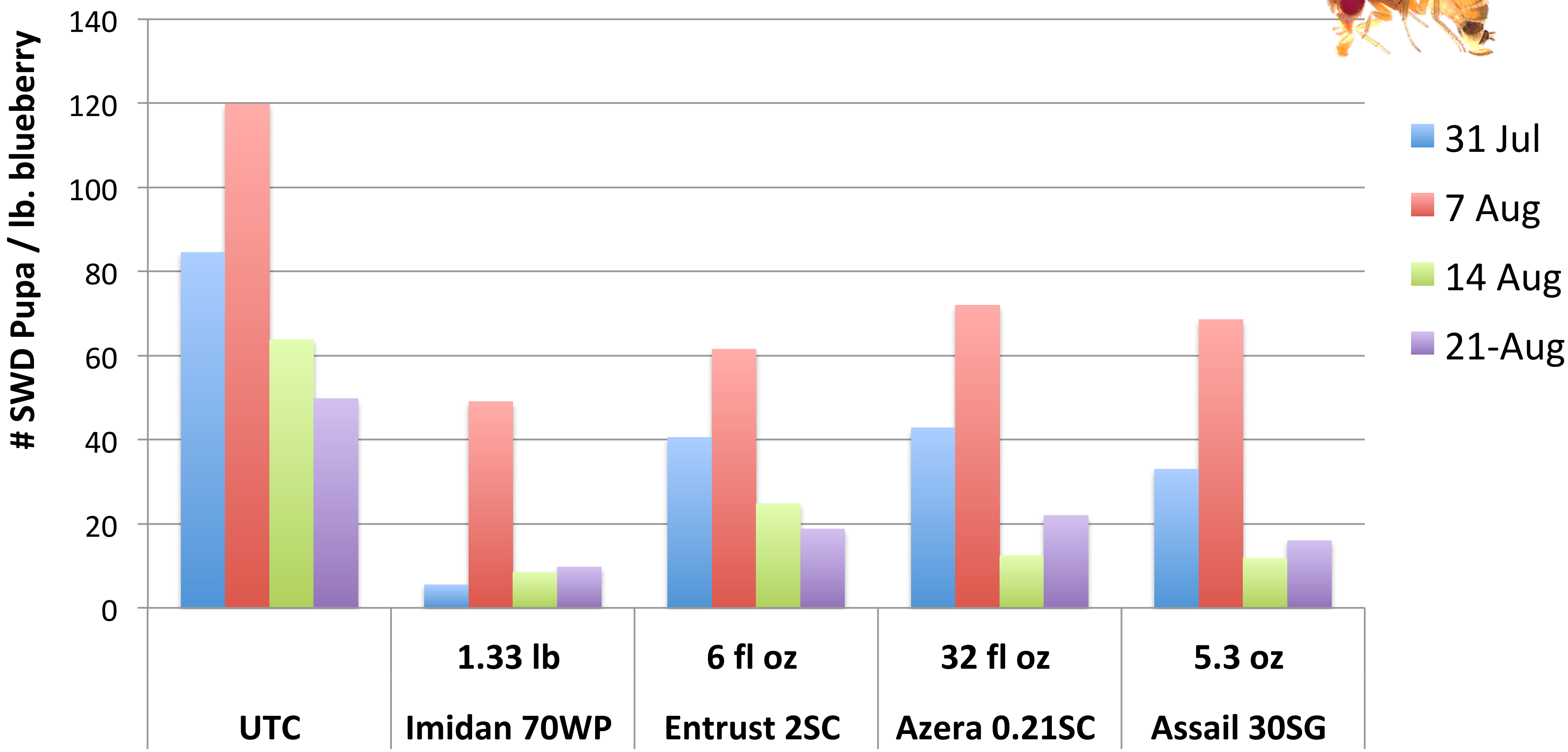
The spinosyn targets binding sites on nicotinic acetylcholine receptors (nAChRs) of the insect nervous system, disrupts acetylcholine and neurotransmission.

The trade name for the organic formulation **Entrust** Naturalyte (1.25-2.0 oz/A) or Entrust SC (4-6 fl oz/A) 2(ee) is limited to 6 applications per season.

Research has shown that efficacy of spinosad against SWD is enhanced when a feeding stimulant (cane sugar) is added to the spray solution (2 lb/100 gallons).

Spinosad (Entrust SC)
OMRI

Managing SWD in Blueberry
Fennville, Michigan 2017 (J. Wise)



Biological Insecticides

II. Biopesticides: Toxins produced by organisms, laboratory reared and manufactured.

Fungus: *Nosema maddoxi* sp. nov. (Microsporidia, Nosematidae)

A species of simple fungi called Microsporidia is a naturally occurring widespread pathogen of the Green Stink Bug Chinavia hilaris (Say) and the Brown Marmorated Stink Bug (BMSB) Halyomorpha halys (Stål).

Has been found to produce over 60% infection rates during overwintering aggregation of BMSB. Increases rate of mortality, decreases fecundity (egg laying) and longevity.

J Eukaryot Microbiol. 2018 May;65(3):315-330. doi: 10.1111/jeu.12475. Epub 2017 Nov 8.

Biological Insecticides

IV. **Natural products** such as oils, fatty acids or soaps, repellents

- **Horticultural oils** during pre-bloom on tree fruit
  a. Pear psylla as ovipositional deterrent, significant reduces 1st generation nymphs.
  b. Season long control of psylla using 1% every 14d in 'dilute applications' (100GPA) will significantly reduce injury from psylla & reduce leaf drop from fabraea.
  c. A 1% application will significantly reduce San Jose Scale in pear and apple with complete coverage of the canopy
  d. Summer use of oil* at 1% will manage European and Two Spotted Spider Mite

* Do not use 14d on either side of Captan fungicide application. Phytotoxicity can occur

Table 12 **Evaluations of Insecticide Schedules for Controlling Pear Psylla on Pear** [a]
Hudson Valley Research Laboratory, Highland, NY - 2018

Treatment / Formulation	Rate	Honeydew % / shoot	Phytotoxicity to Bosc Pear Foliage % severity Interior-tree	Mid-Tree	Outer-Tree
1. BioCover Oil	128.0 fl.oz./100	23.3 b	13.1 c	8.8 b	6.8
2. BioCover Oil + Surround	128.0 fl.oz./100 12.5 lbs./100	19.9 b	30.0 abc	28.8 ab	23.8
3. Surround BioCover Oil	12.5 lbs./100 128.0 fl.oz./100	26.7 b	19.9 bc	16.3 b	9.8
4. BioCover Oil Venerate XC + oil	128.0 fl.oz./100 1.0 qt./A	41.2 ab	26.7 abc	23.8 ab	25.0
5. BioCover Oil Venerate XC + oil	128.0 fl.oz./100 2.0 qt./A	48.3 ab	29.6 abc	32.5 ab	18.8
6. BioCover Oil Grandevo WDG	256.0 fl.oz./100 2.0 lb./A	57.1 ab	42.9 b	40.0 ab	33.8
7. BioCover Oil BotaniGard Certis CX-10282	256.0 fl.oz./100 2.0 qt./100 2.0 qt./100	59.6 ab	32.5 abc	33.8 ab	23.8
8. UTC		71.4 a	50.4 a	56.3 a	38.8
P value for transformed data		0.0051	0.0011	0.0066	0.644

[a] Seasonal evaluations made on 'Bartlett'.

Biological Insecticides

V. **Attractants**: synthetic or natural products to lure and trap pests.

Raspberry: **Spotted wing drosophila:** Developed a 3.25” diameter disk using apple cider vinegar, red raspberry concentrate & boric acid to attract and kill (ATK) SWD adults. 50-88% reduction In egg laying in raspberry

BMSB Management: duel pheromone, insecticide netting and light: Integrated use of ATK along the orchard wooded edge interface to reduce migration into crops near harvest.

Vegetable & Tree Fruit

Free Standing Solar LED ATK + Phermone for Monitoring *the* Stink Bug Complex

Biological Insecticides

VI. **Barrier Film:** Inert coating to reduce attractiveness of host plant

Surround WP: Kaolin clay based barrier film stratified onto foliage, tree architecture and fruit

- Changes the color and texture to reduce insect attraction to the crop and subsequent infestation.
- Reduces sun burn injury to fruit during periods of high heat and light to reduce tree stress.

Table 12 **Evaluations of Insecticide Schedules for Controlling Pear Psylla on Pear [a]**
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5. BioCover Oil Venerate XC + oil	128.0 fl.oz./100 2.0 qt./A	48.3 ab	29.6 abc	32.5 ab	18.8
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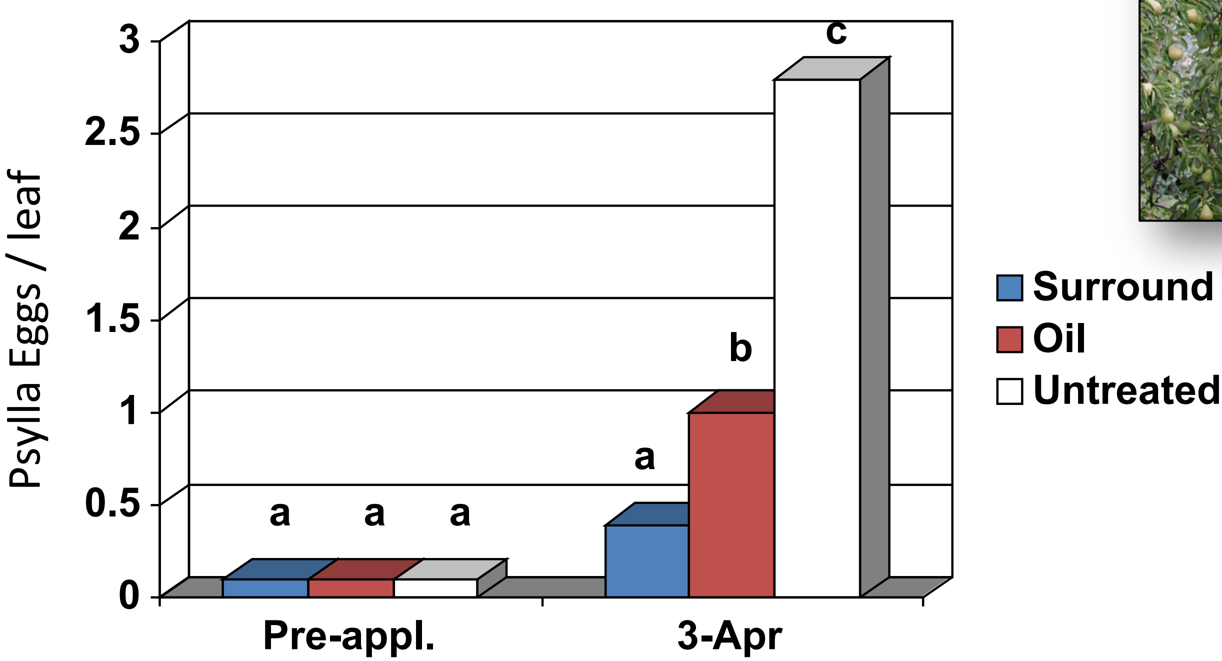
8. UTC		71.4 a	50.4 a	56.3 a	38.8
P value for transformed data		0.0051	0.0011	0.0066	0.644

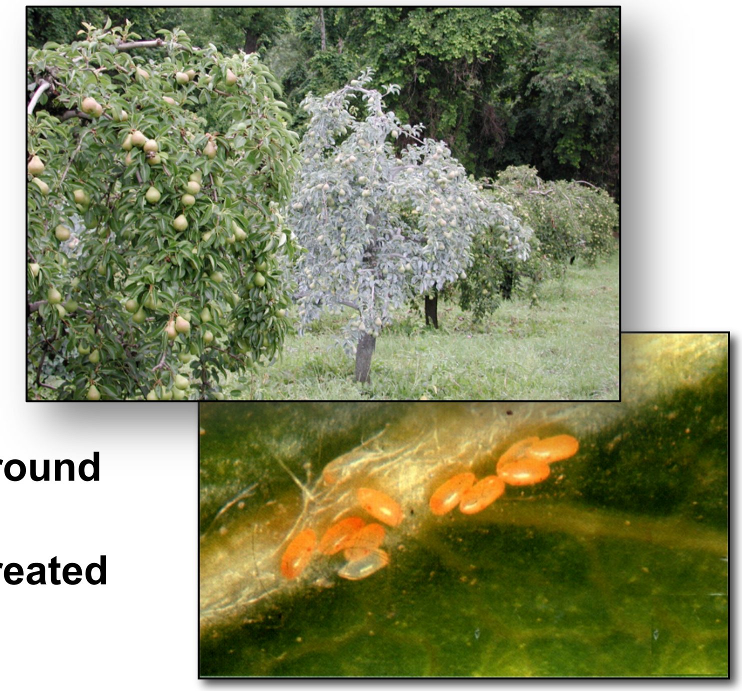
[a] Seasonal evaluations made on 'Bartlett'.

Management Options for Pear Psylla

Barrier / Particle Films: Surround WP acts as an ovipositional deterrent
Kaolin clay formulation produces a reflective white film and texture to disorient and repel adults from trees.

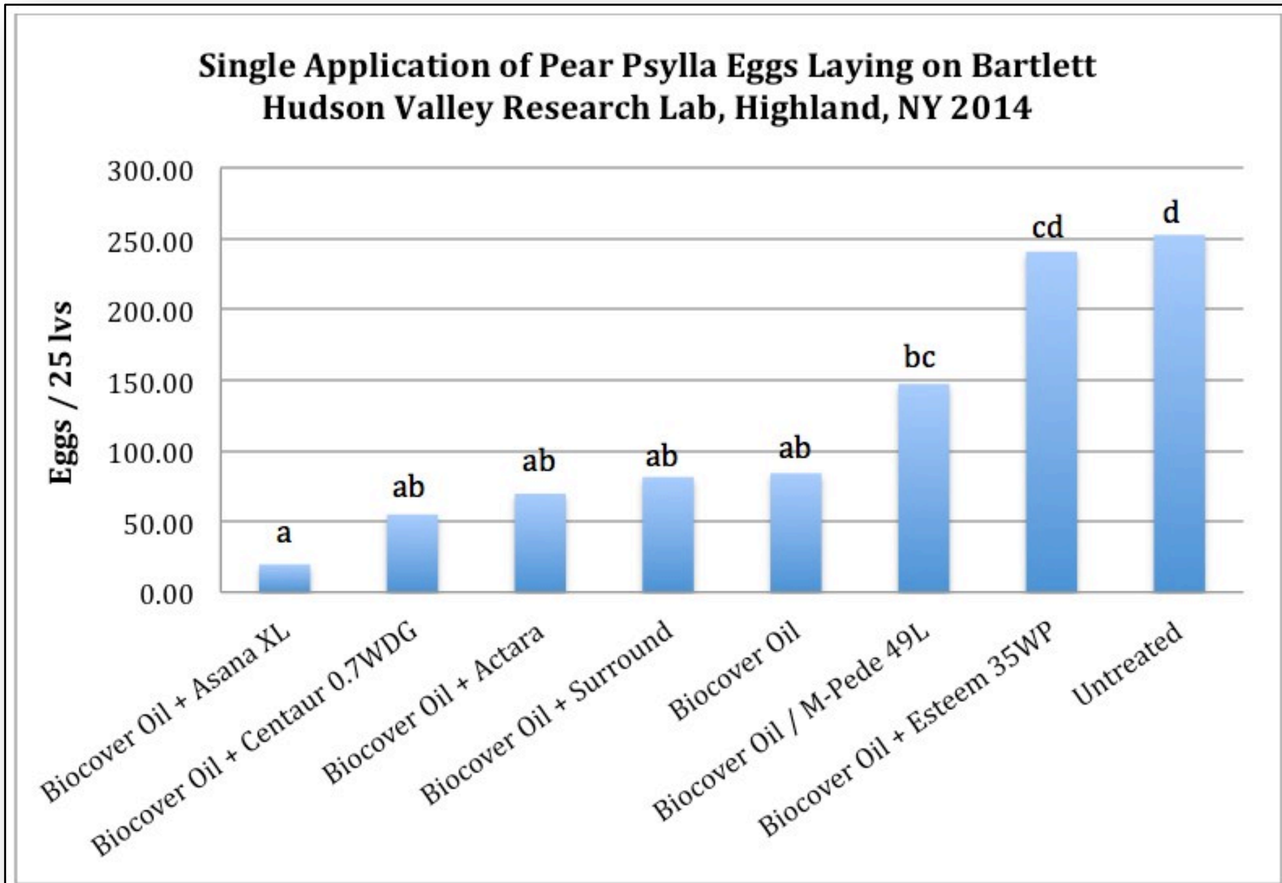


2011: F=20.7, P=.0001



Management Options for Pear Psylla Eggs

Surround WP as an ovipositional deterrent at DD, GC, WB for 1st generation
Actara at PF
Horticultural oil at 10-14d intervals to end of season.



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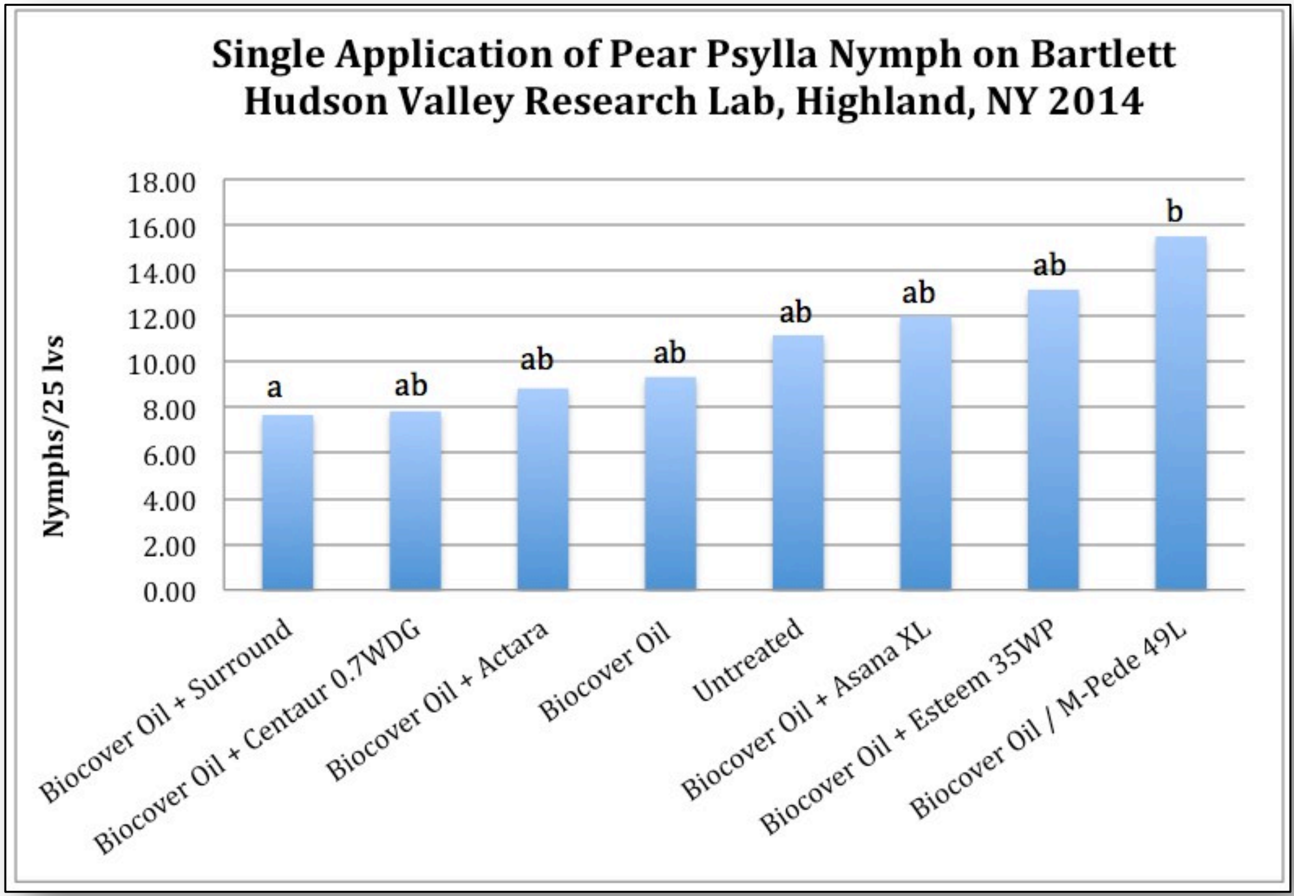
Management Options for Pear Psylla Nymph

Barrier Film: Surround WP impact on nymph populations.



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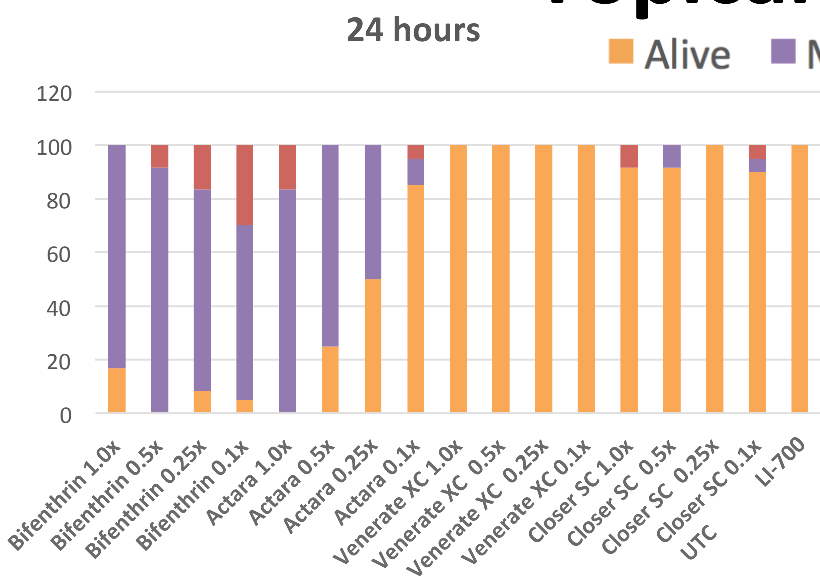
BMSB Feeding and Mortality Comparison Using Actara, Bifenthure, Closer, Venerate Topical Bioassay and Residual Treated Apple.

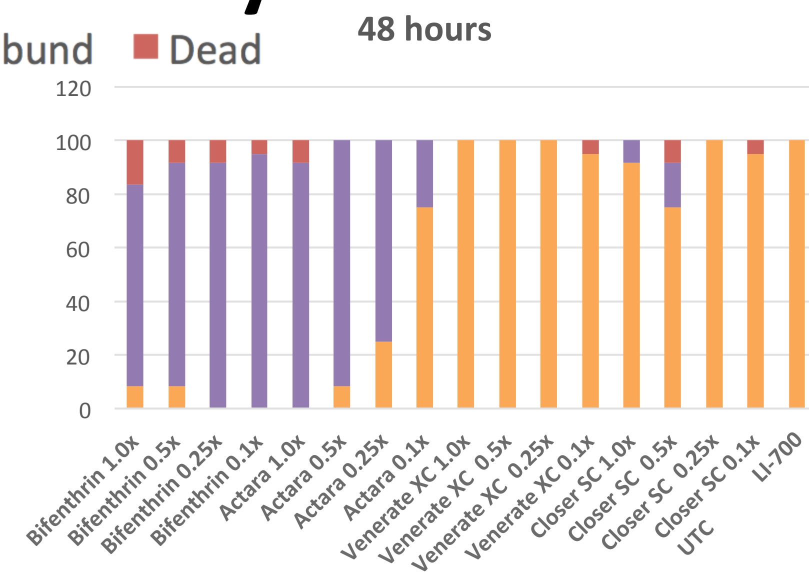
Topical Bioassays

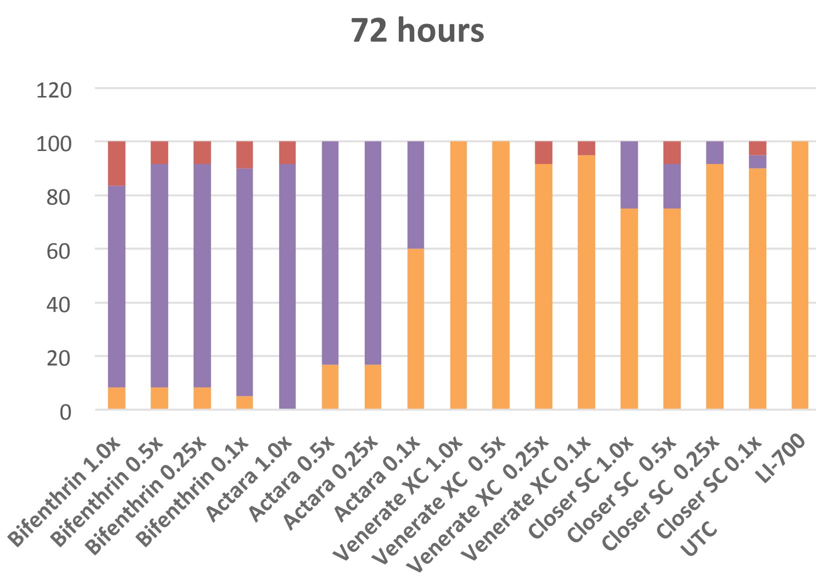
- Stink bug were separated into individual cups for male and female
- Individuals received 2 uL of distilled water, 0.25% LI700, individual insecticide to the dorsal thoractic plate.
  - Treatments: **Actara, Bifenthure, Closer, Venerate, UTC**
  - Doses: 1, 0.5, 0.25, and 0.1 times the top label rate
- Status (alive, moribund, dead) was recorded at 24, 48, 72 hours and at 7d post treatment.

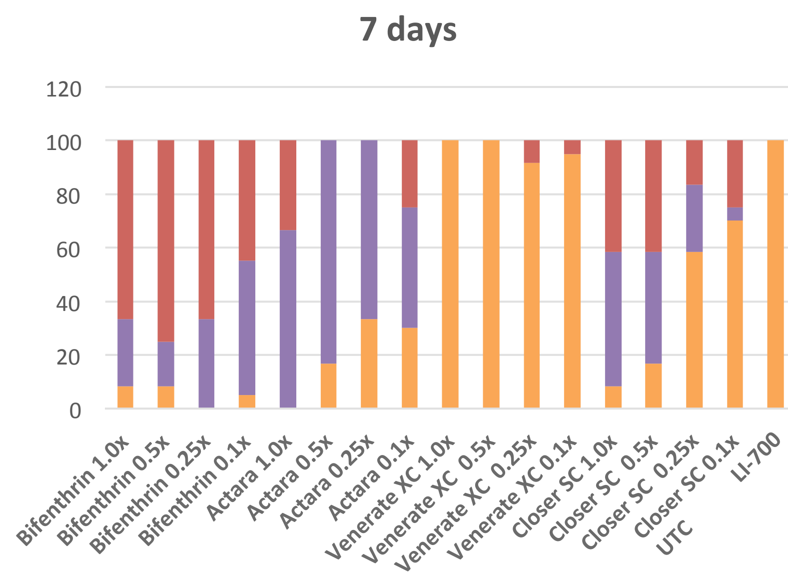
Topical Bioassays

Alive Moribund Dead









2017 Field Application

Applications using tractor mounted sprayer on 20th Sept. 300 psi. using dilute handgun applications:

- Closure SC 5.75 fl.oz./A
- Bifrenthrin SC 32.0 fl.oz./A
- Actara 25 WDG 5.5 oz./A
- Venerate XC 128.0 fl.oz./A
- BMSB adults placement beginning on 20th Sept.
  - 24h; 48hr; 72hr placement. Collection made after 7d of placement.
  - Insects placed inside portion cups with screened bottoms, rubber band onto the north side of the tree and the north side of those apples to reduce sun exposure.
  - BMSB adults placed into growth chamber supplied green beans
  - Observations made 2x/wk
  - Fruit harvested on 12 Oct. for fruit feeding evaluations

Field Application: Fruit Residue

BMBS placed on apples 24 hours after pesticide application on Sep.20, 2017.					
	Number of feeding sites per fruit	**Dimpling per fruit**	**Corking per fruit**	**Clean fruit (%)**	**Survival (%)**
Closer SC	0.1a	0.1a	0.1a	90a	0a
Bifenthrin	0a	0a	0a	100a	0a
Actara	0a	0a	0a	100a	0a
Venerate	0a	0a	0a	100a	20a
UTC	0.7a	0a	0a	50a	20a
Kruskal-Walis Test, Prob>ChiSq	0.0115	0.8123	0.8123	0.0136	0.3071

Means followed by the same letter are not significantly different by Steel-Dwass Method at α=0.05 Apples were rated on Oct.12, 2017. BMSB survival were recorded 7 days after exposure to the fruit.

Field Application: Fruit Residue

BMBS placed on apples 48 hours after pesticide application on Sep.20, 2017.					
	Number of feeding sites per fruit	Dimpling per fruit	Corking per fruit	Clean fruit (%)	Survival (%)
Closer SC	0.1b	0.1a	0.1a	90a	0a
Bifenthrin	0b	0a	0a	100a	10a
Actara	0.1b	0.1a	0.1a	90a	0a
Venerate	0.2ab	0a	0a	80ab	40a
UTC	1.2a	0.4a	0.4a	20b	0a
Kruskal-Walis Test, Prob>ChiSq	0.0001	0.4313	0.4313	0.0002	0.0873

Means followed by the same letter are not significantly different by Steel-Dwass Method at α=0.05 Apples were rated on Oct.12, 2017. BMSB survival were recorded 7 days after exposure to the fruit.

Field Application: Fruit Residue

BMBS placed on apples 72 hours after pesticide application on Sep.20, 2017.					
	Number of feeding sites per fruit	**Dimpling per fruit**	**Corking per fruit**	**Clean fruit (%)**	**Survival (%)**
Closer SC	0.2a	0.2a	0.2a	90a	80a
Bifenthrin	0.2a	0.2a	0.2a	90a	10b
Actara	0.2a	0.2a	0.2a	90a	100a
Venerate	0.1a	0a	0a	90a	70a
UTC	1.2a	0.1a	0.1a	40a	30ab
Kruskal-Walis Test, Prob>ChiSq	0.0687	0.9254	0.9254	0.0795	0.0006

Means followed by the same letter are not significantly different by Steel-Dwass Method at α=0.05 Apples were rated on Oct.12, 2017. BMSB survival were recorded 7 days after exposure to the fruit.

BMSB Adult Topical Treatment

- Applications were made topically to BMSB adults on 28th Sept. placed on the tree in 10 replicates for each treatment
  - Insects were placed inside portion cups with screened bottoms with a rubber band on the north side of the tree and the north side of those apples to reduce sun exposure as much as possible
- Fruit was collected on 12th October for fruit feeding evaluations

BMSB Adult Topical Treatment

BMSB treated topically on Sep.28, 2017 and placed on apples for 7 days.					
	Number of feeding sites per fruit	**Dimpling per fruit**	**Corking per fruit**	**Clean fruit (%)**	**Survival (%)**
Closer SC	0.3a	0.2a	0.2a	90a	30b
Bifenthrin	0.1a	0a	0a	90a	0b
Actara	0a	0a	0a	100a	10b
Venerate	0a	0a	0a	100a	100a
UTC	0.9a	0a	0a	60a	90a
Kruskal-Walis Test, Prob>ChiSq	0.1288	0.5348	0.5348	0.1093	<.0001

Means followed by the same letter are not significantly different by Steel-Dwass Method at α=0.05 Apples were rated on Oct.12, 2017. BMSB survival were recorded 7 days after exposure to the fruit.

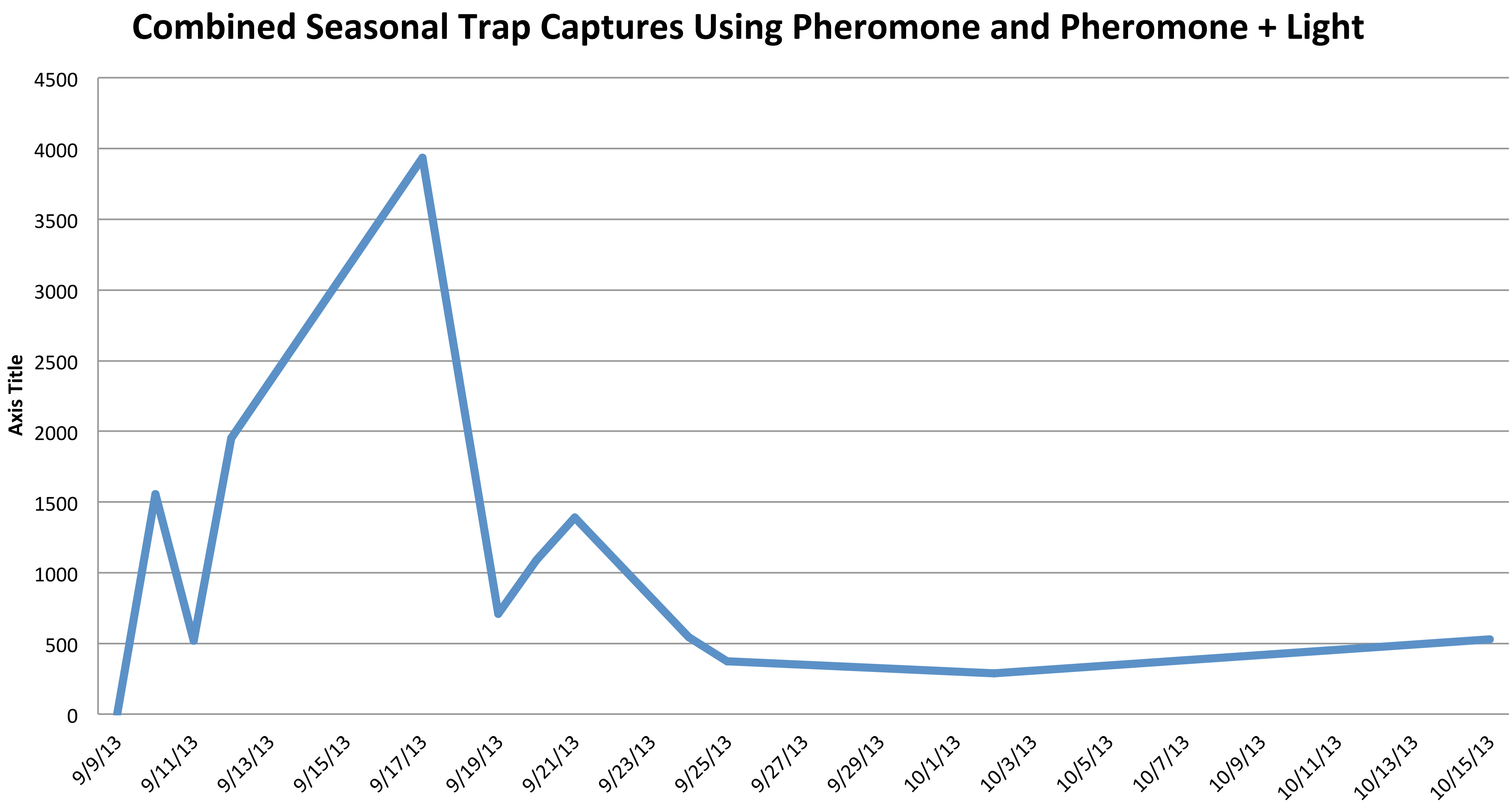
Attract and Kill Netting in Orchard
Duel Pheromone + Insecticide

Proceedures Con’t

- Generator + 500W Halogen light directed toward the field population of BMSB.
- Plastic sheets to define location and number of BMSB trap and kill data.
- Study was designed to:
  1. Determine the attractiveness of lights with net relative to net alone
  2. Determine the number of BMSB observed coming from field versus forest sides of trap

Hudson Valley Research Laboratory

Studies of the Brown Marmorated Stink Bug, *Halyomorpha halys* (Stål), in New York State



(September – 15 October: Total BMSB = 12,894

Free Standing Solar LED ATK + Phermone for Monitoring *the* Stink Bug Complex

Cornell University

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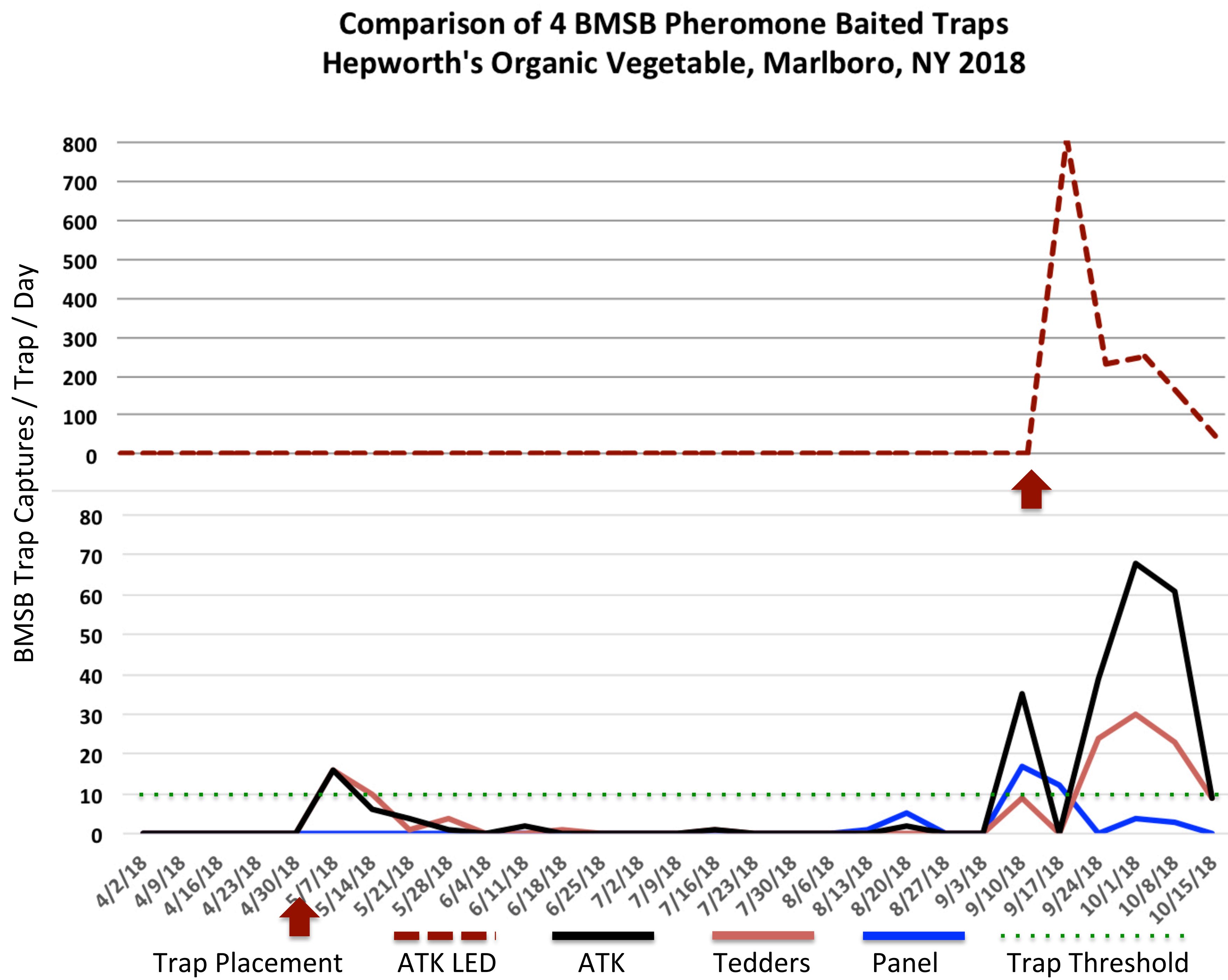
Stink Bug Complex: Attract & Kill (AtK)



Comparison of 4 BMSB Pheromone Baited Traps
Hepworth's Organic Vegetable, Marlboro, NY 2018
BMSB Trap Captures / Trap / Day
800
700
600
500
400
300
200
100
0
80
70
60
50
40
30
20
10
0
4/2/18
4/9/18
4/16/18
4/23/18
4/30/18
5/7/18
5/14/18
5/21/18
5/28/18
6/4/18
6/11/18
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6/25/18
7/2/18
7/9/18
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8/6/18
8/13/18
8/20/18
8/27/18
9/3/18
9/10/18
9/17/18
9/24/18
10/1/18
10/8/18
10/15/18
Trap Placement
ATK LED
ATK
Tedders
Panel
Trap Threshold

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

Male

Female

Spotted Wing Drosophila

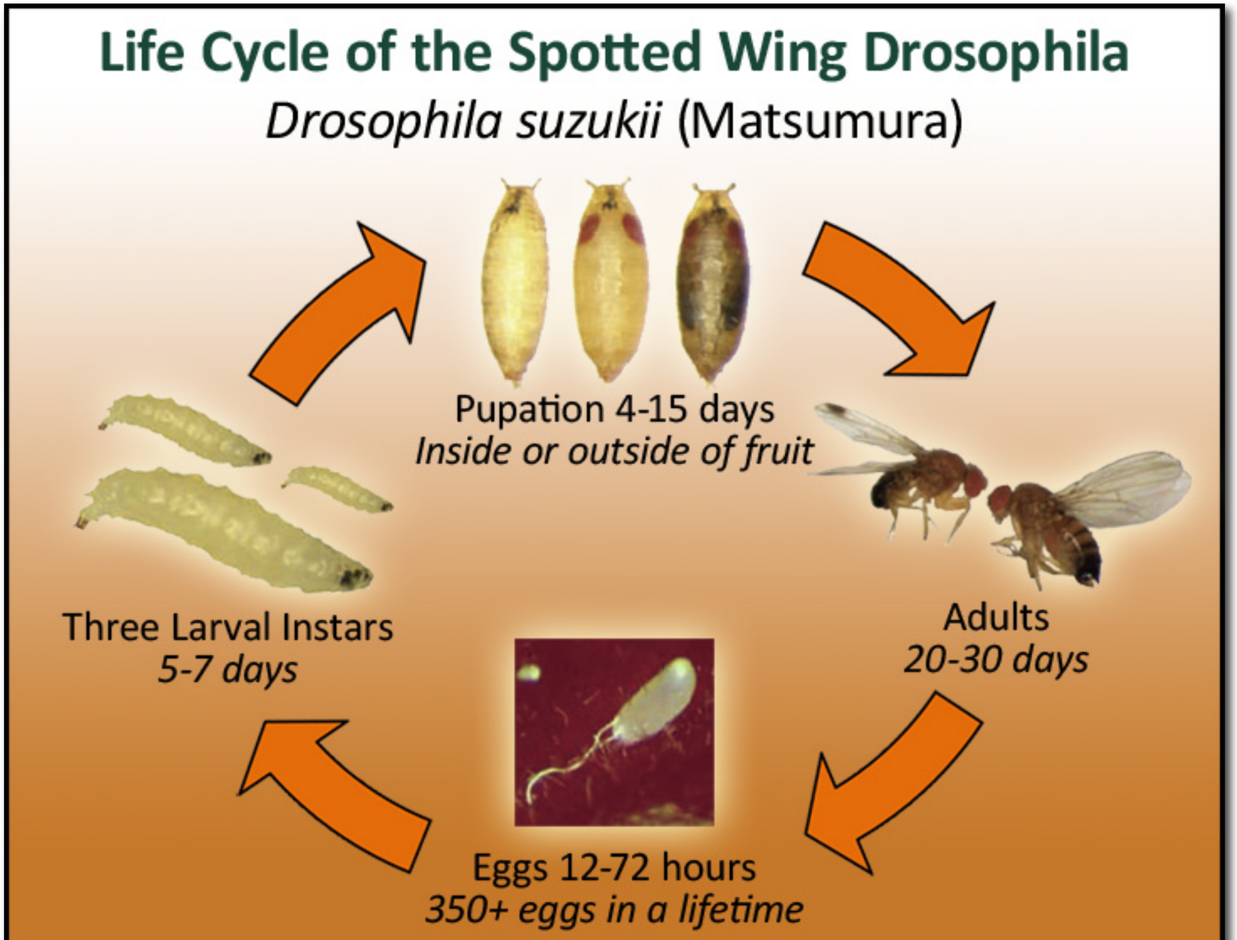
Peter Jentsch
Extension Associate

Success of SWD in Small Fruit

Occupies a relatively non-competitive niche

- Able to penetrate and oviposit into un-ripened fruit using a highly scleratinized & serrated ovipositor .

Reproductive Success of SWD in Small Fruit



- Optimal development is at 65-70°F, **~12 day** generation time.
- Adult flies live for 3-6 weeks, and females can lay over 300 eggs.
- Limited by high heat in summer and by winter cold. But, SWD populations are found in cold regions of Japan.
- 3-10 generations in NY

Fruit Affected by SWD

Highest risk

Strawberries

Raspberries

Cherries (Late var,)

Nectarines

Blueberries

Blackberries

Moderate risk

Peaches

Grapes

Pears

Apples

Tomato

Alternate hosts

Wild plants with berries, such as…

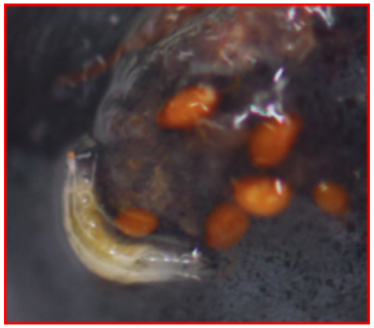
Tartarian Honeysuckle

Snowberry

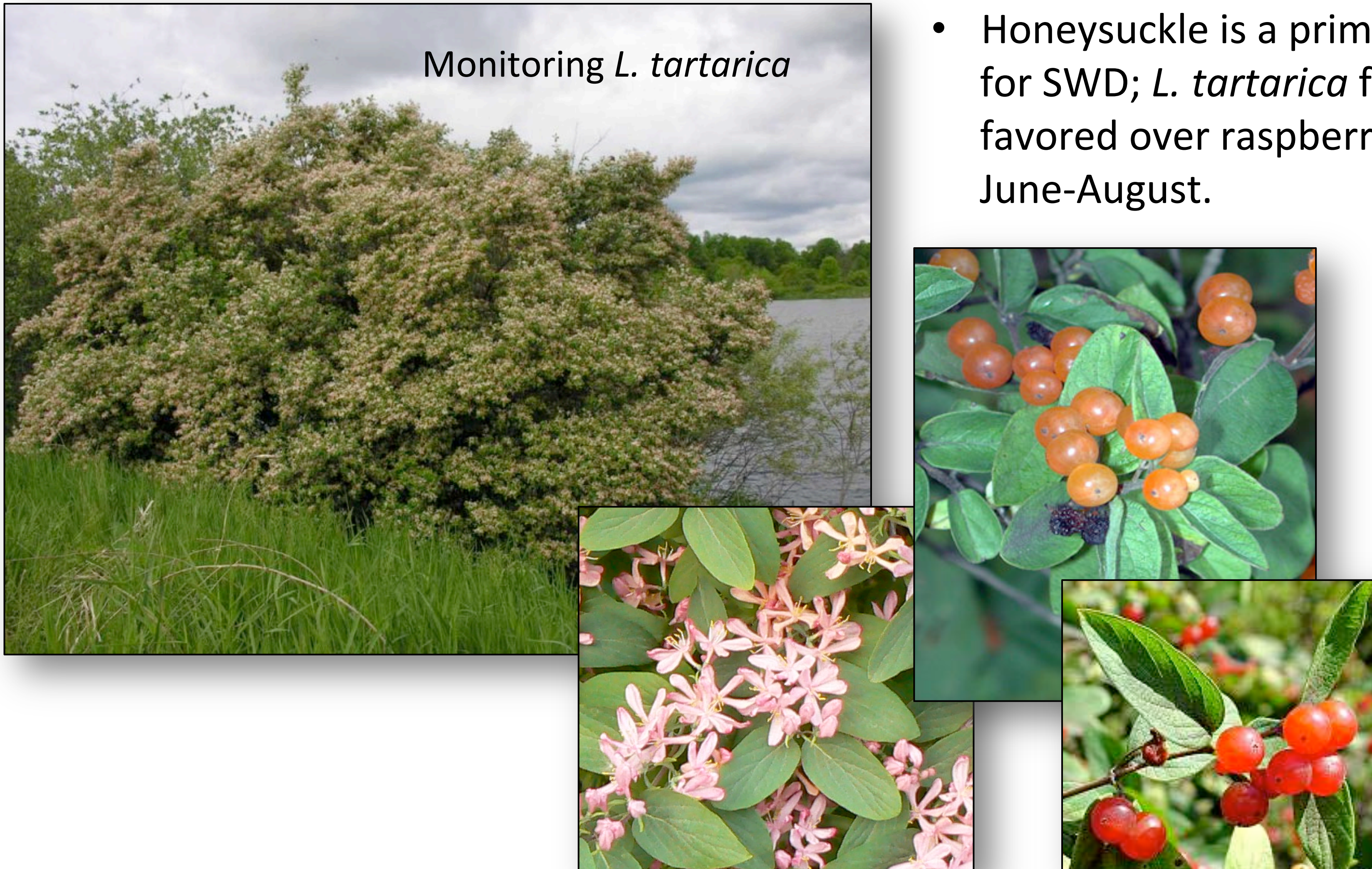
Elderberry

Pokeweed

Dogwood

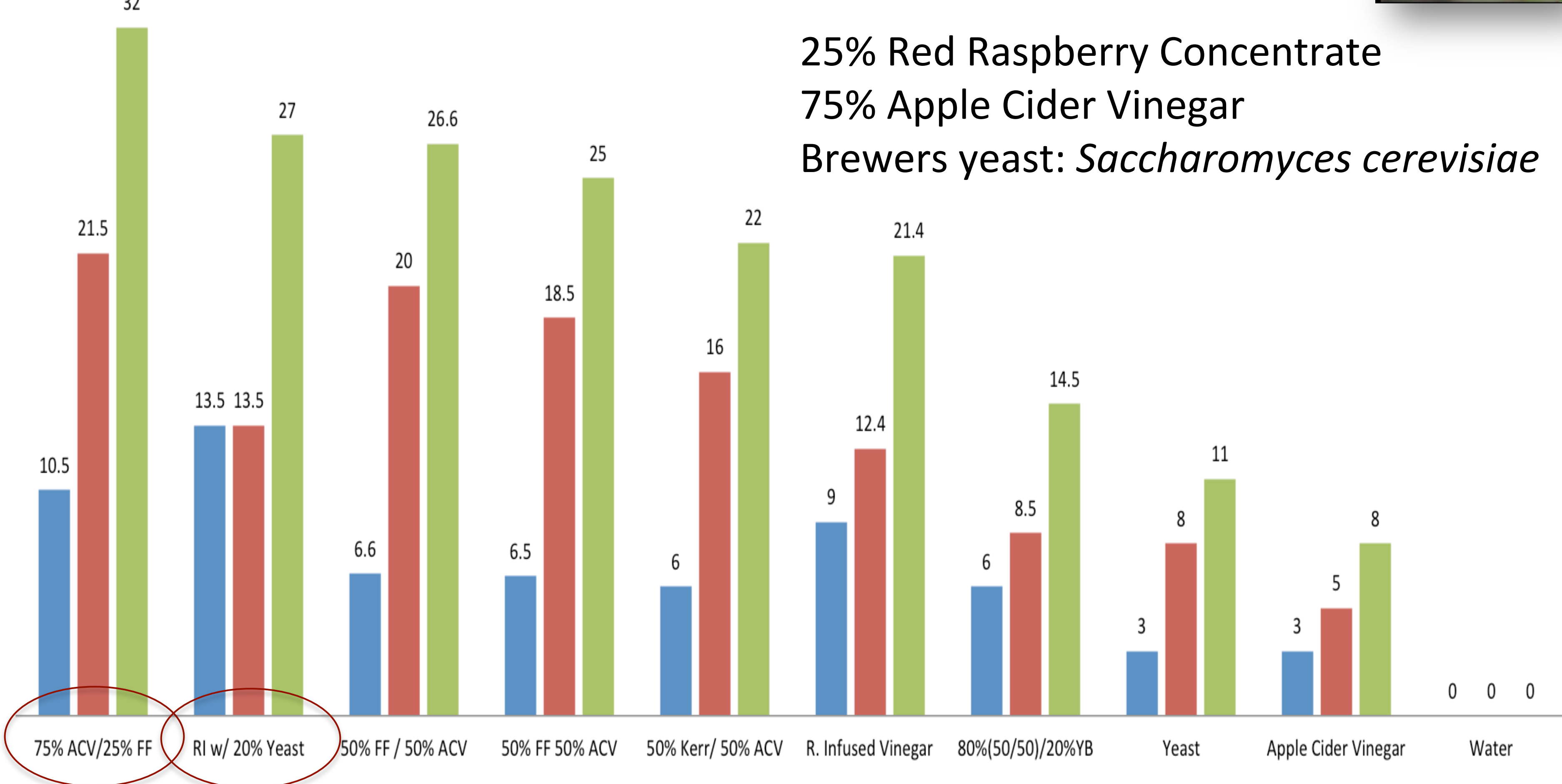
SWD Alternate Host: Population Development in the HV



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

SWD Adult Preference Binary Choice Tests
Mean # AtK Component Attractiveness

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



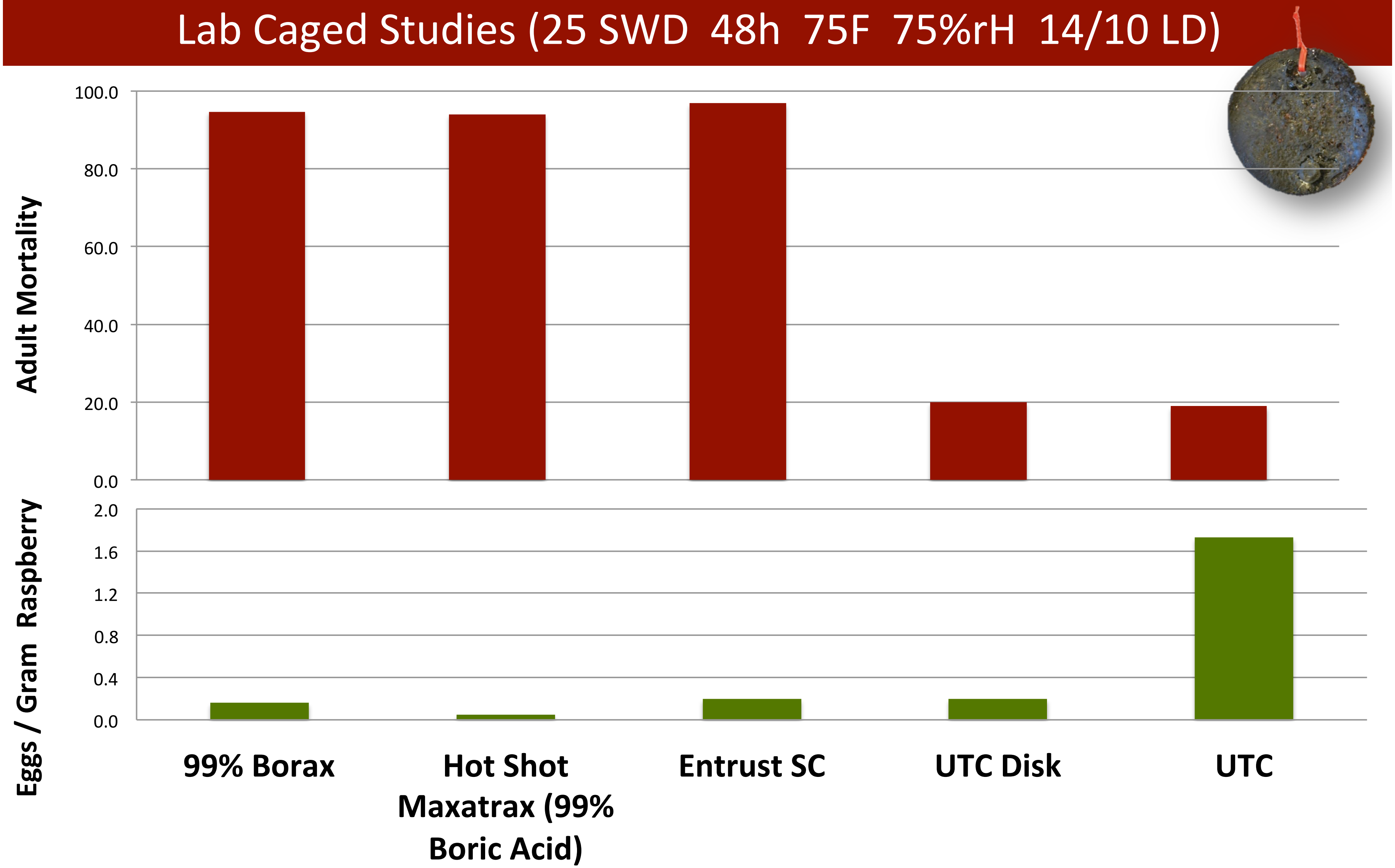
Methods: Development of Attract and Kill for Management of SWD in Small Fruit

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

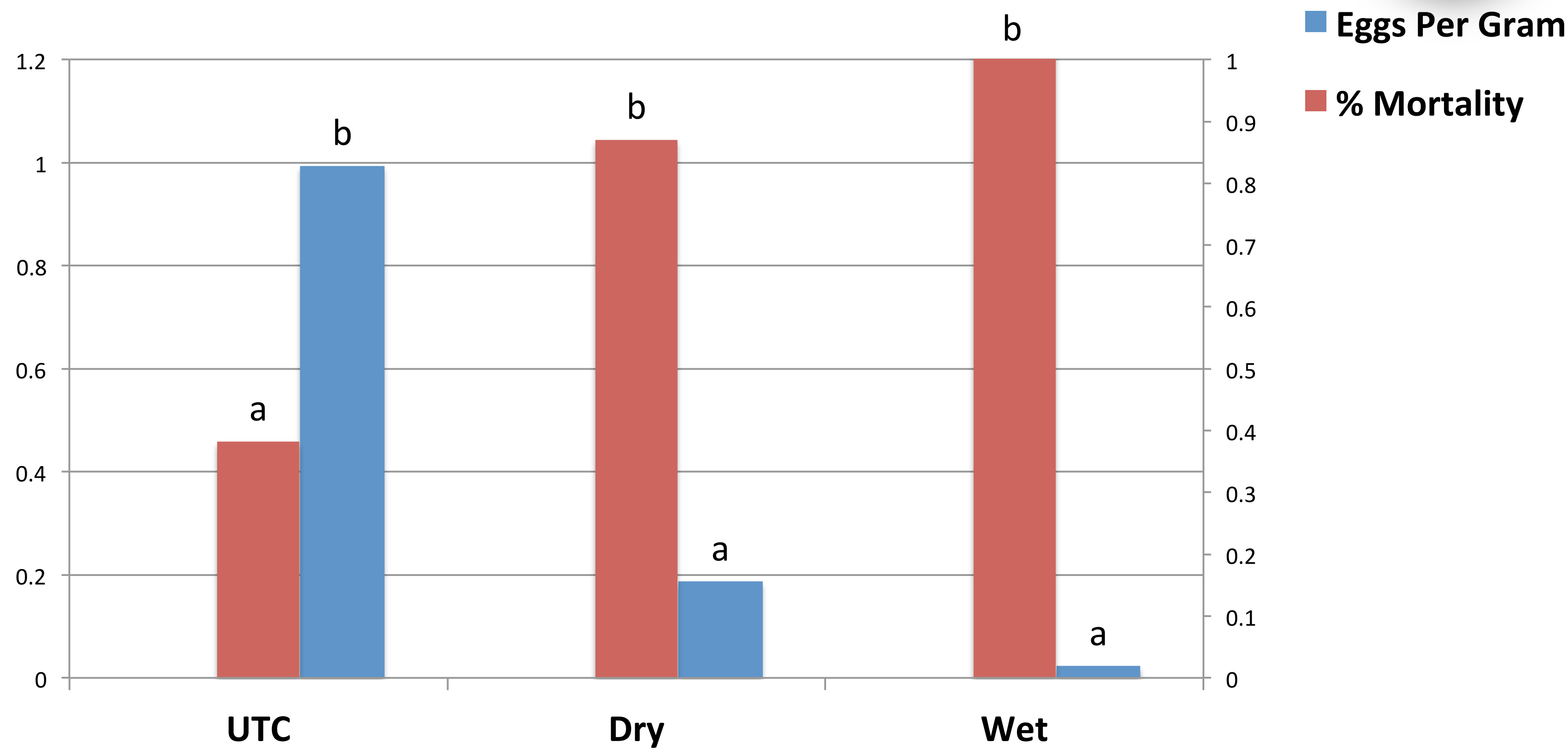
Attract and Kill Station Efficacy

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



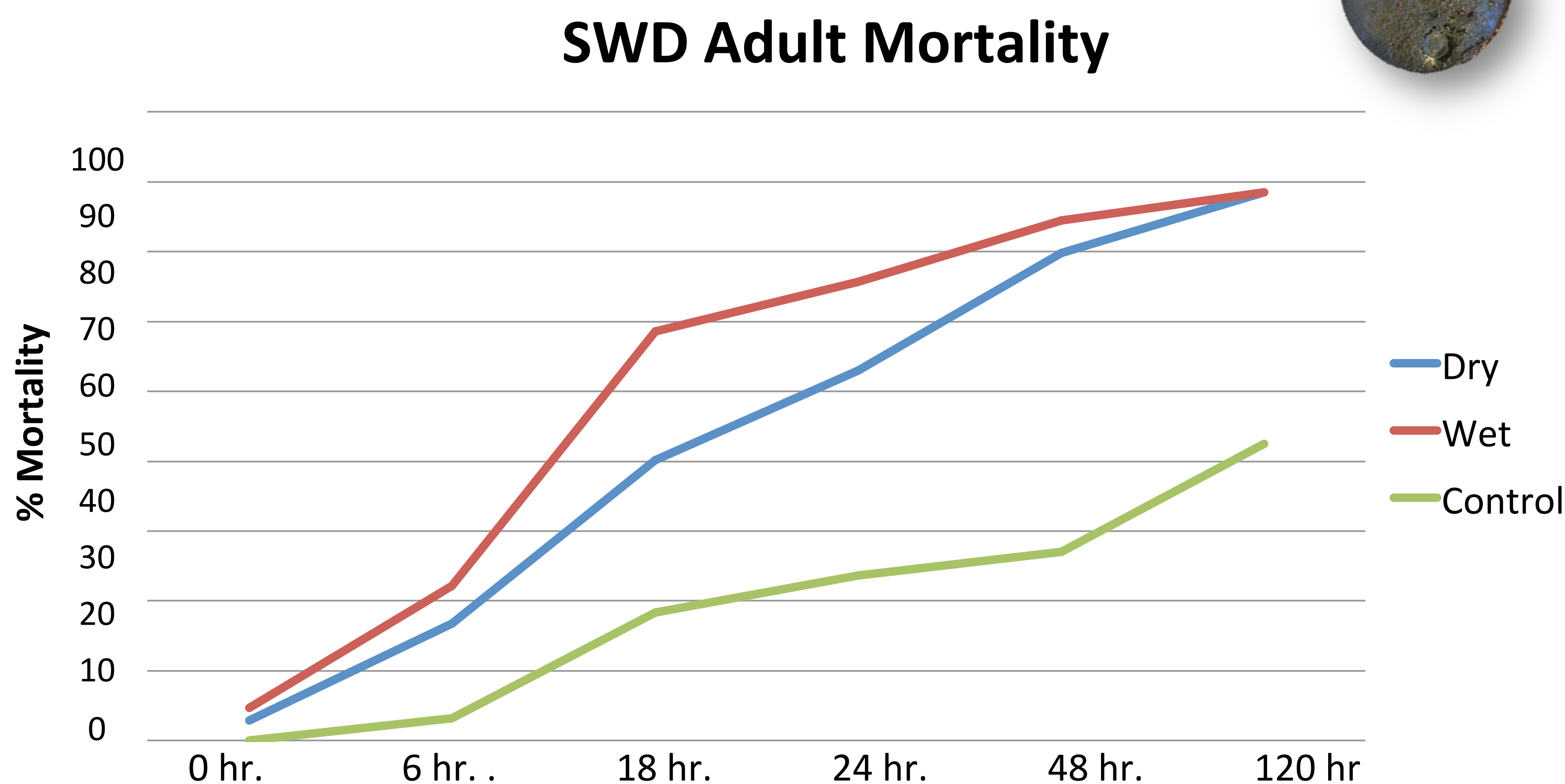
Attract and Kill Station Recharge Efficacy

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



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

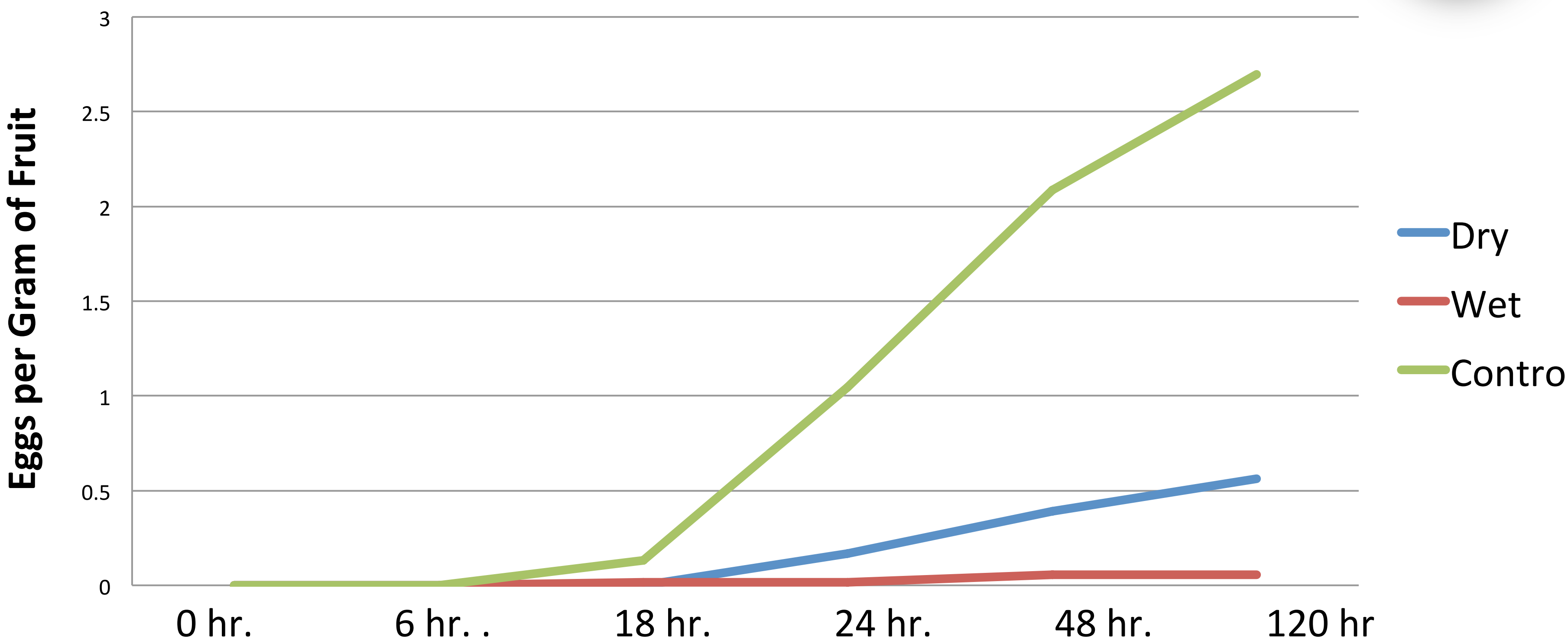
Attract and Kill Station Recharge Efficacy



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

Attract and Kill Station Recharge Efficacy

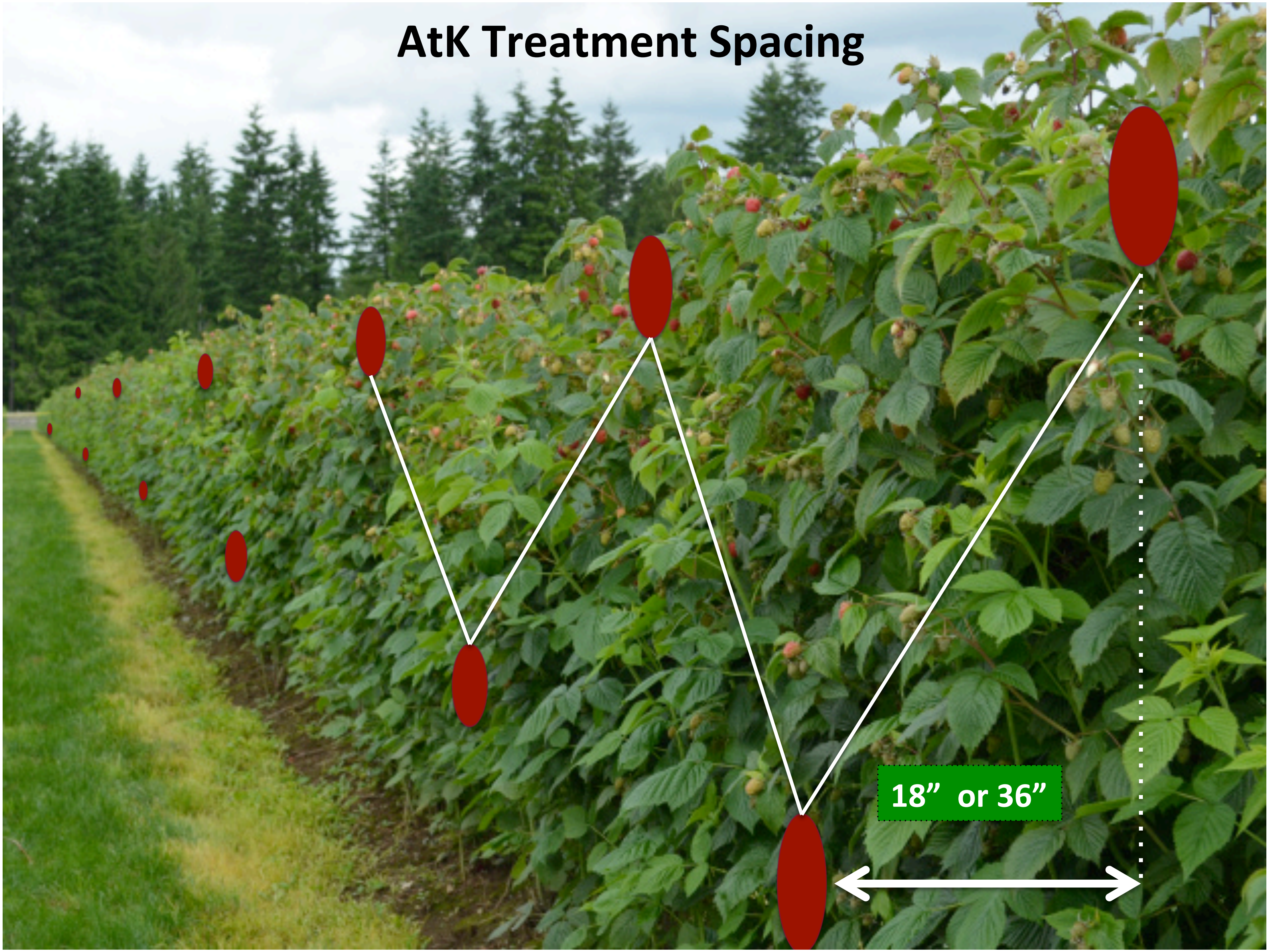
Eggs Per Gram in Raspberry Fruit



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

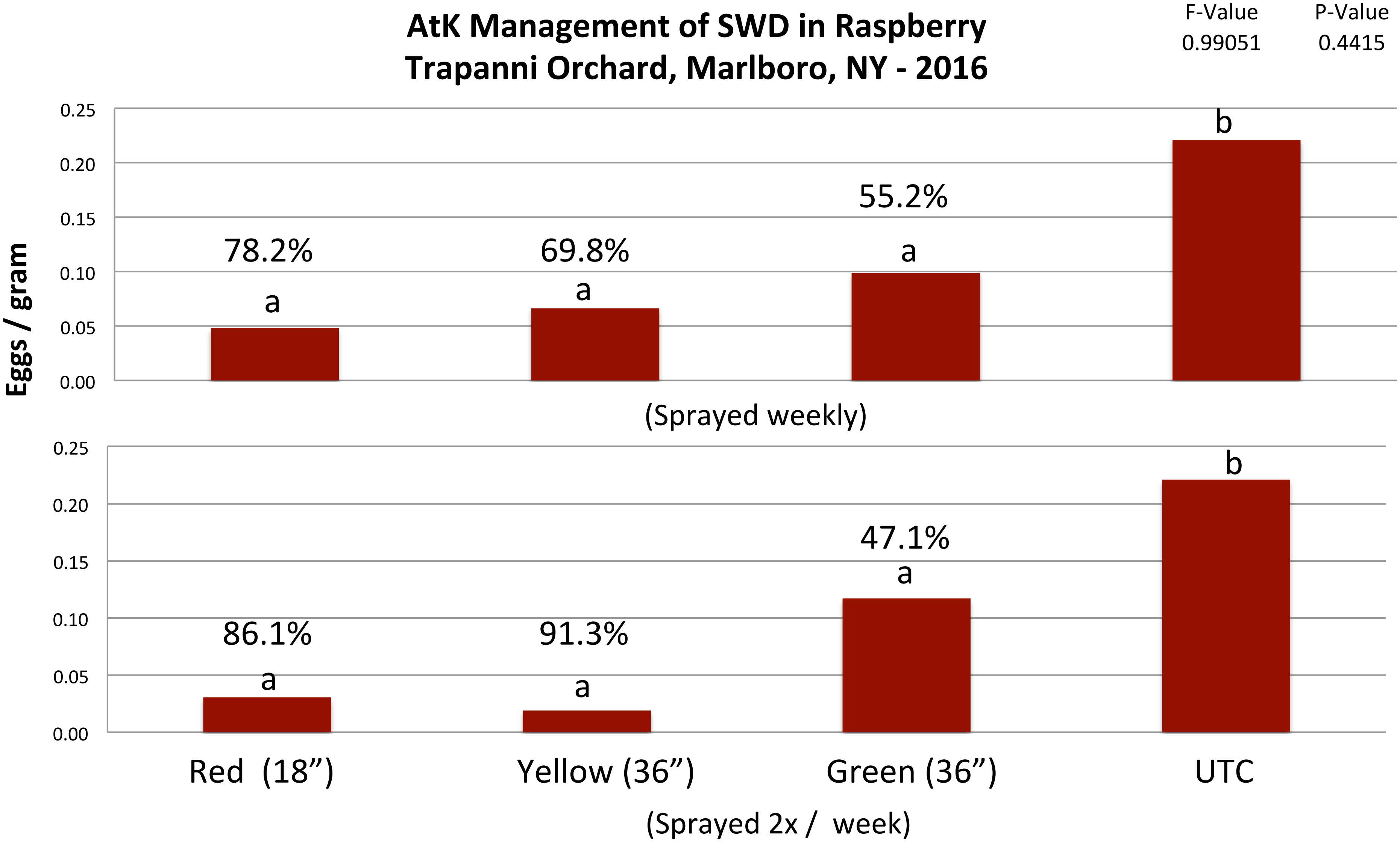
Attraction of Drosophila to AtK from Morning Dew

June 14th – September 19th 8:30 AM,

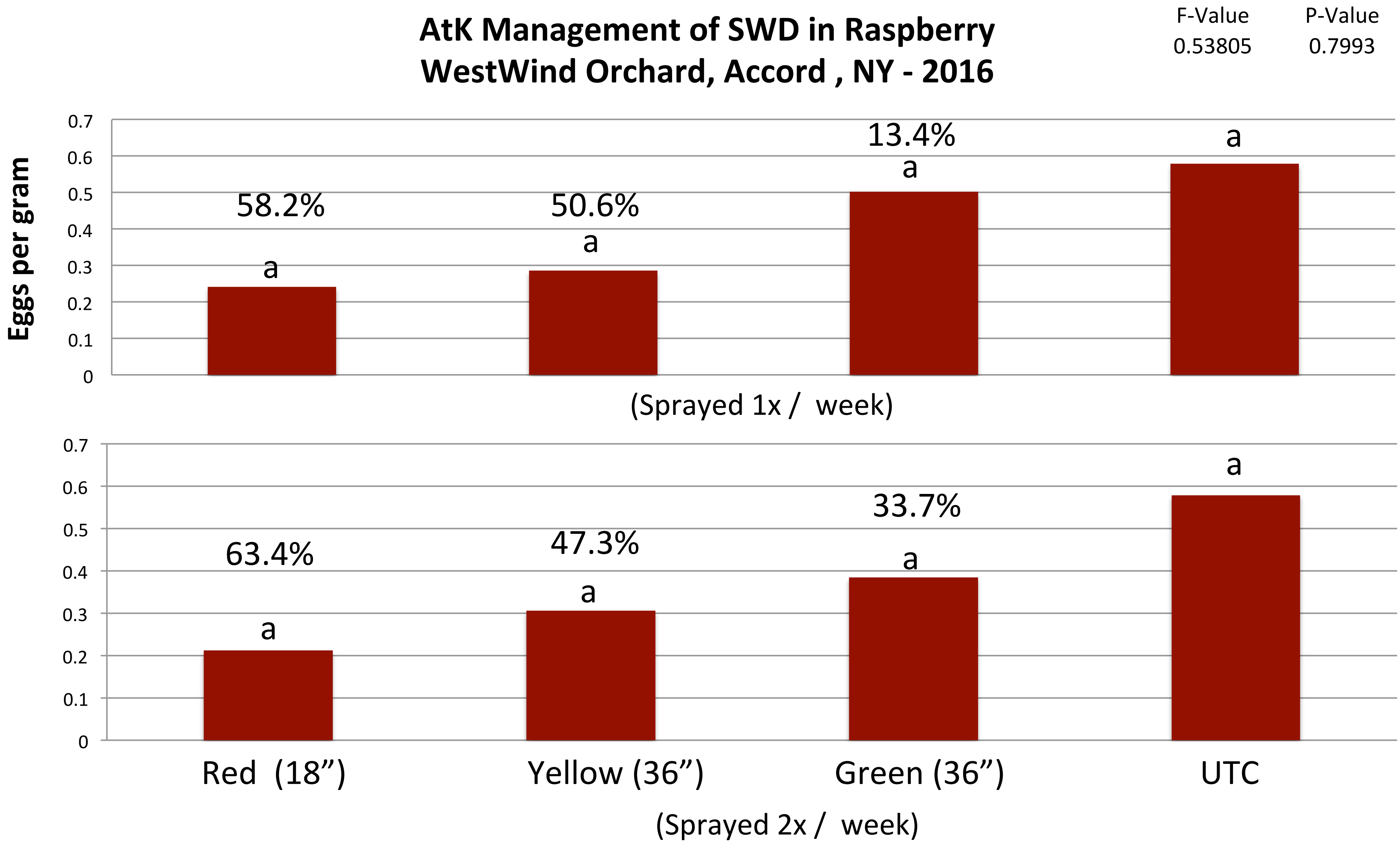


AtK Treatment Spacing
18” or 36”

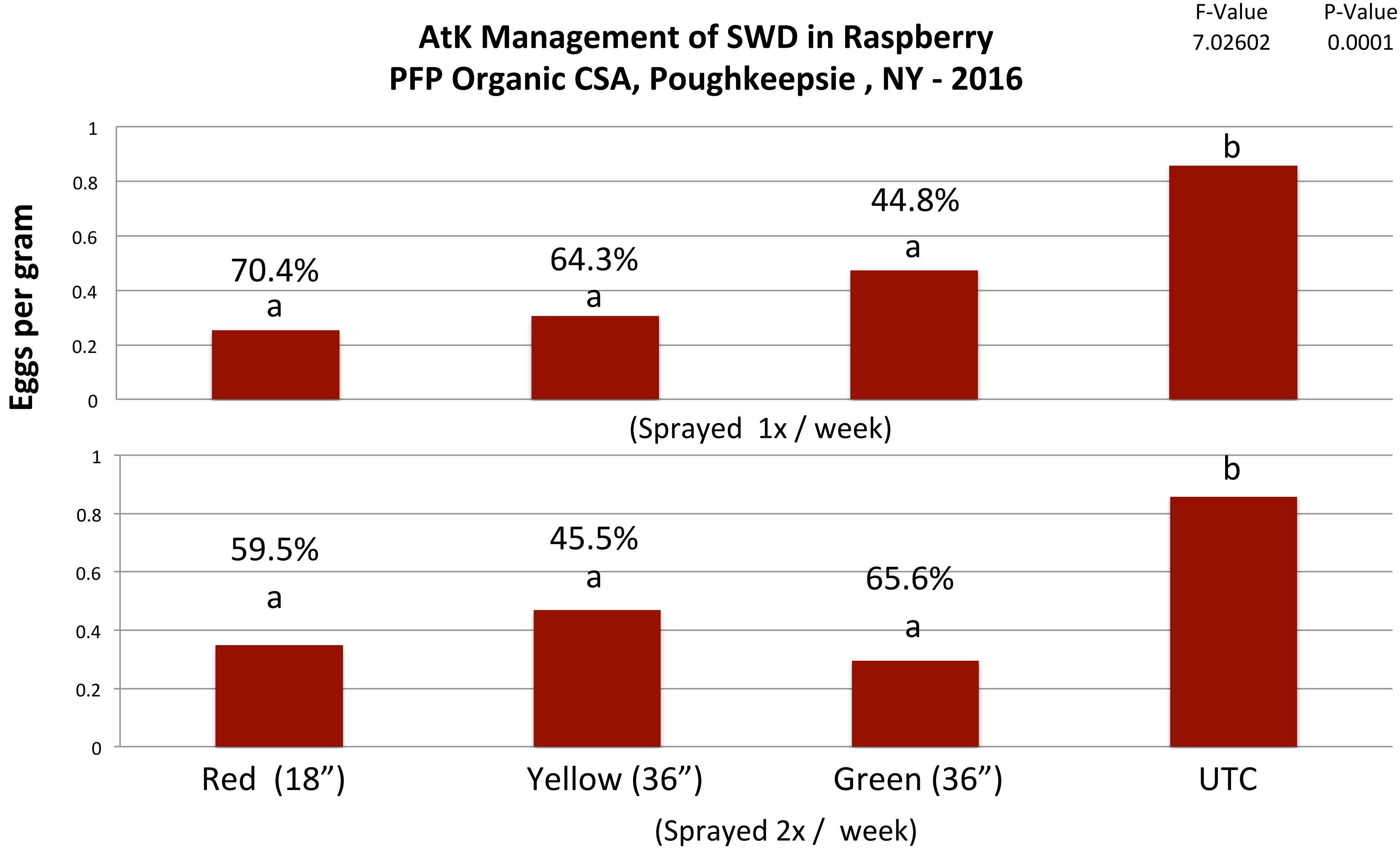
SWD Damage Means in Raspberry Fruit



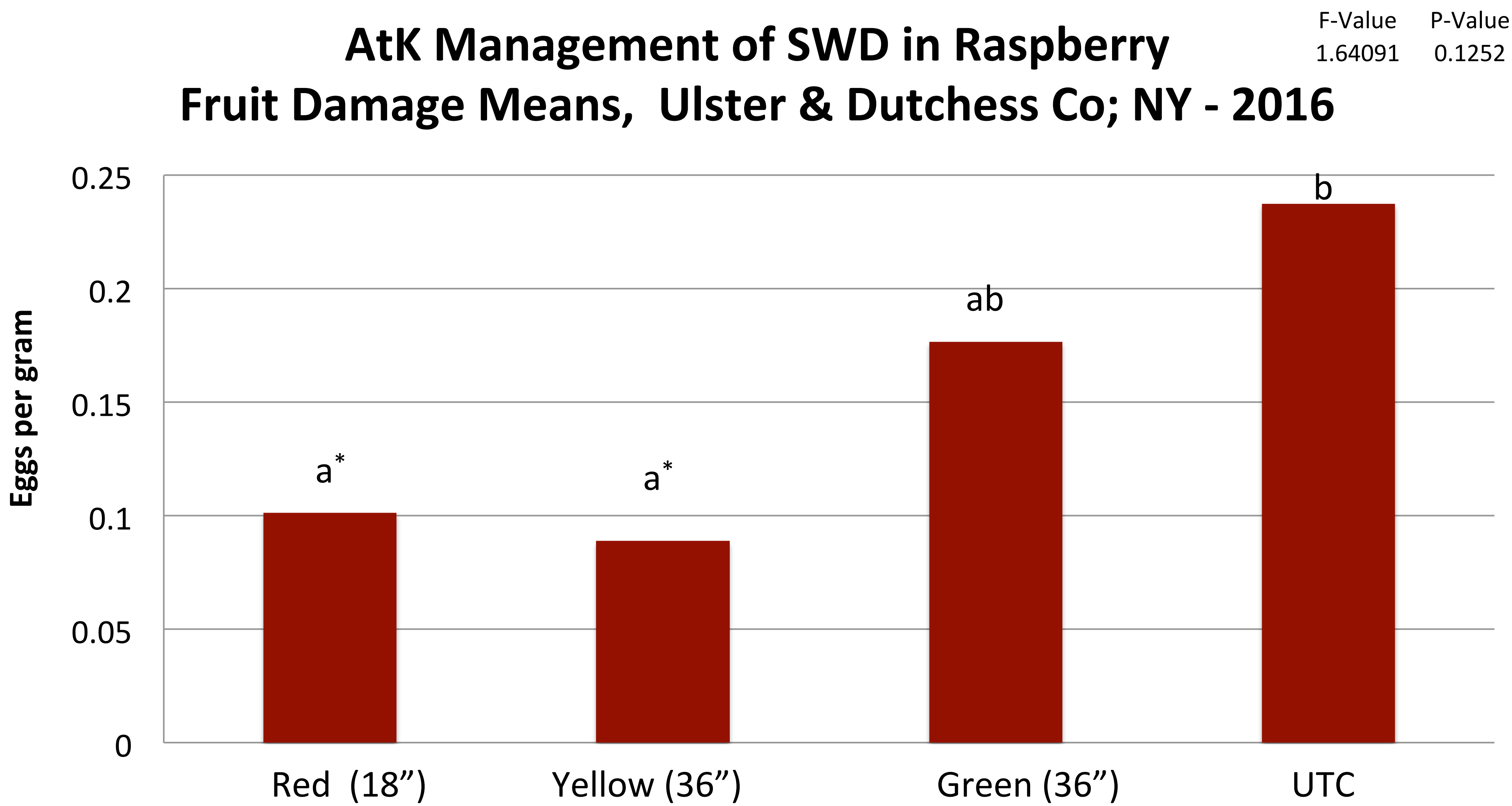
SWD Damage Means in Raspberry Fruit



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.

Conclusion

- Each biological requires an understanding for the specific pest to be managed management
- Timing, environmental conditions, rates are all very critical for success.
- Not all biologicals are as effective as chemical synthetic materials and may need to be placed into the crops augmented with synthetic materials to be successful.
- However, many of these products can be used successfully to achieve control of the insect pest complex. More exaluations need to be conducted as these products improve over time.