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
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

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

Hawaii 1980
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

<table>
<thead>
<tr>
<th>Year</th>
<th>New York</th>
<th>Michigan</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>Sept. 11 (Columbia/Suffolk)</td>
<td>Aug. 7</td>
</tr>
<tr>
<td>2012</td>
<td>July 20 (Ulster)</td>
<td>June 3</td>
</tr>
<tr>
<td>2013</td>
<td>June 11 (Ontario)</td>
<td>May 26</td>
</tr>
<tr>
<td>2014</td>
<td>July 22 (Orleans)</td>
<td>June 15</td>
</tr>
<tr>
<td>2015</td>
<td>June 22 (Orange)</td>
<td>June 28</td>
</tr>
<tr>
<td>2016</td>
<td>July 7 (Dutchess)</td>
<td>June 19</td>
</tr>
<tr>
<td>2017</td>
<td>May 31 (Orleans)</td>
<td>May 19</td>
</tr>
<tr>
<td>June 27 (Dutchess)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>May 22 (Erie)</td>
<td>May 19</td>
</tr>
</tbody>
</table>
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

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**Spring**
- **Egg**: 72 hrs
- **Larvae**: 7 days
- **Pupae**: 15 days
- **Adult**: 30 days
- **Egg to Adult**: 25.0 days

**Summer**
- **Egg**: 12 hrs
- **Larvae**: 5 days
- **Pupae**: 4 days
- **Adult**: 20-30 days
- **Egg to Adult**: 9.5 days

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**Generational Intervals**

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

- June
- July
- August
- September
- October
- Nov.
Life Cycle of the Spotted Wing Drosophila

*Drosophila suzukii* (Matsumurai)

## Fruit Affected by SWD

<table>
<thead>
<tr>
<th>Highest risk</th>
<th>Moderate risk</th>
<th>Alternate hosts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strawberries</td>
<td>Peaches</td>
<td>Wild plants with berries, such as...</td>
</tr>
<tr>
<td><strong>Raspberries</strong></td>
<td><strong>Grapes</strong></td>
<td><strong>Tartarian Honeysuckle</strong></td>
</tr>
<tr>
<td>Cherries (Tart pref.)</td>
<td>Pears</td>
<td>Snowberry</td>
</tr>
<tr>
<td>Nectarines</td>
<td>Apples</td>
<td>Elderberry</td>
</tr>
<tr>
<td>Blueberries</td>
<td>Tomato</td>
<td>Pokeweed</td>
</tr>
<tr>
<td><strong>Blackberries</strong></td>
<td></td>
<td>Dogwood</td>
</tr>
</tbody>
</table>

![Images of fruit affected by SWD]
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 1\textsuperscript{st} eggs in fruit

Application: Begin at 1\textsuperscript{st} observation of egg laying.
# Chemistries for Fruit Production: SWD

<table>
<thead>
<tr>
<th>Class</th>
<th>IRAC Code</th>
<th>Examples</th>
<th>SWD Efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organophosphates</td>
<td>1B</td>
<td>Malathion</td>
<td>Excellent to good</td>
</tr>
<tr>
<td>Pyrethroids</td>
<td>3A</td>
<td>Brigade, Danitol, Mustang Max</td>
<td>Excellent</td>
</tr>
<tr>
<td>Spinosyns</td>
<td>5</td>
<td>Delegate, Entrust</td>
<td>Excellent to good</td>
</tr>
<tr>
<td>Neonicotinoids</td>
<td>4A</td>
<td>Assail</td>
<td>Good to poor</td>
</tr>
<tr>
<td>Carbamates</td>
<td>1A</td>
<td>Sevin</td>
<td>Good to poor</td>
</tr>
<tr>
<td>Diamide</td>
<td>28</td>
<td>Exirel*</td>
<td>Excellent to good</td>
</tr>
</tbody>
</table>
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
• **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
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
• 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.

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.

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

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

<table>
<thead>
<tr>
<th>Insecticide Product</th>
<th>Active Ingredient (IRAC Group)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malathion 5EC</td>
<td>malathion (IRAC 1B)</td>
</tr>
<tr>
<td>Imidan 70W</td>
<td>phosmet IRAC 1B</td>
</tr>
<tr>
<td>Assail 30SG</td>
<td>acetamiprid (IRAC 4A)</td>
</tr>
<tr>
<td>Scorpion 35 SL</td>
<td>dinotefuran (IRAC 4A)</td>
</tr>
<tr>
<td>Brigade EC</td>
<td>bifenthrin (IRAC 3A)</td>
</tr>
<tr>
<td>Mutang Max</td>
<td>zeta-cypermethrin (IRAC 3A)</td>
</tr>
<tr>
<td>Pyganic EC 1.4</td>
<td>pyrethrin (IRAC 3A)</td>
</tr>
<tr>
<td>Triple Crown</td>
<td>bifenthrin, imidaclorpid, zeta-cypermethrin (IRAC 3A, 4A)</td>
</tr>
<tr>
<td>Delegate WG</td>
<td>spinetoram (IRAC 5)</td>
</tr>
<tr>
<td>Entrust SC</td>
<td>spinosad (IRAC 5)</td>
</tr>
<tr>
<td>Exirel</td>
<td>cyazypyr (IRAC 28)</td>
</tr>
<tr>
<td>BotaniGard; Mycotrol</td>
<td><em>Beauveria bassiana</em> strain GHA</td>
</tr>
<tr>
<td>BaLEnce</td>
<td><em>Beauveria bassiana</em> Diptera-specific strain (HF23)</td>
</tr>
<tr>
<td>Boric Acid</td>
<td>99% Boric Acid</td>
</tr>
<tr>
<td>Hot Shot Maxattrax Roach Powder</td>
<td>99% Boric Acid formulated</td>
</tr>
</tbody>
</table>
Attract and Kill Station Efficacy
Lab Caged Studies (25 SWD  48h  75F  75%rH  14/10 LD)

Adult Mortality

Eggs / Gram Raspberry

- 99% Borax
- Hot Shot
- Maxatrax (99% Boric Acid)
- Entrust SC
- UTC Disk
- UTC

Hudson Valley Research Laboratory
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

SWD Adult Mortality

% Mortality

0 hr.  6 hr.  18 hr.  24 hr.  48 hr.  120 hr

Dry  Wet  Control

1% A.I. Entrust (spinosad-Dow)
Attract and Kill Station Recharge Efficacy

Eggs per Gram in Raspberry Fruit

Eggs per Gram of Fruit

0 0.5 1 1.5 2 2.5 3

0 hr. 6 hr. 18 hr. 24 hr. 48 hr. 120 hr

Dry
Wet
Control

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

- Initial weight loss of $\geq 50\%$ in 30 hours and overall seasonal weight loss of 70%.
- Extended rain events increase fluctuations in AtK disk weight.
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,
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
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
### 3 Raspberry Plantings on 3 Farm sites in two NY counties

**1 Conventional & 2 Organic Production Systems**

<table>
<thead>
<tr>
<th>Rep I</th>
<th>Rep II</th>
<th>Rep III</th>
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<tbody>
<tr>
<td><img src="image1.png" alt="Diagram" /></td>
<td><img src="image2.png" alt="Diagram" /></td>
<td><img src="image3.png" alt="Diagram" /></td>
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</table>

**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

18” or 36”
SWD Damage Means in Raspberry Fruit

AtK Management of SWD in Raspberry
Trapani Orchard, Marlboro, NY - 2016

Eggs / gram

(Sprayed weekly)

<table>
<thead>
<tr>
<th>Eggs / gram</th>
<th>Red (18”)</th>
<th>Yellow (36”)</th>
<th>Green (36”)</th>
<th>UTC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>78.2%</td>
<td>69.8%</td>
<td>55.2%</td>
<td></td>
</tr>
<tr>
<td>Yellow</td>
<td></td>
<td></td>
<td></td>
<td>a</td>
</tr>
<tr>
<td>Green</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UTC</td>
<td></td>
<td></td>
<td></td>
<td>b</td>
</tr>
</tbody>
</table>

(Sprayed 2x / week)

<table>
<thead>
<tr>
<th>Eggs / gram</th>
<th>Red (18”)</th>
<th>Yellow (36”)</th>
<th>Green (36”)</th>
<th>UTC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>86.1%</td>
<td>91.3%</td>
<td>47.1%</td>
<td></td>
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<tr>
<td>Yellow</td>
<td></td>
<td></td>
<td></td>
<td>a</td>
</tr>
<tr>
<td>Green</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UTC</td>
<td></td>
<td></td>
<td></td>
<td>b</td>
</tr>
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</table>

F-Value 0.99051
P-Value 0.4415
AtK Management of SWD in Raspberry
WestWind Orchard, Accord, NY - 2016

<table>
<thead>
<tr>
<th>Eggs per gram</th>
<th>Red (18”)</th>
<th>Yellow (36”)</th>
<th>Green (36”)</th>
<th>UTC</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Sprayed 1x / week)</td>
<td>58.2%</td>
<td>50.6%</td>
<td>13.4%</td>
<td>a</td>
</tr>
<tr>
<td>(Sprayed 2x / week)</td>
<td>63.4%</td>
<td>47.3%</td>
<td>33.7%</td>
<td>a</td>
</tr>
</tbody>
</table>

F-Value: 0.53805
P-Value: 0.7993

Note: Different letters indicate significant differences at p < 0.05.
SWD Damage Means in Raspberry Fruit

AtK Management of SWD in Raspberry
PFP Organic CSA, Poughkeepsie, NY - 2016

<table>
<thead>
<tr>
<th>Eggs per gram</th>
<th>Red (18&quot;)</th>
<th>Yellow (36&quot;)</th>
<th>Green (36&quot;)</th>
<th>UTC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sprayed 1x / week</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70.4%</td>
<td>a</td>
<td>64.3%</td>
<td>a</td>
<td>44.8%</td>
</tr>
<tr>
<td>Sprayed 2x / week</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>59.5%</td>
<td>a</td>
<td>45.5%</td>
<td>a</td>
<td>65.6%</td>
</tr>
</tbody>
</table>

F-Value: 7.02602
P-Value: 0.0001

(Sprayed 1x / week)
(Sprayed 2x / week)
**Combined Farm & AtK Application Timing**

**AtK Management of SWD in Raspberry**
Fruit Damage Means, Ulster & Dutchess Co; NY - 2016

![Bar chart showing eggs per gram for different fruit stages and UTC.](chart.png)

*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 optimal 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
Our Objectives for Exclusion

1. Reduce SWD infestation to raspberry
2. Reduce chemical inputs for control
3. Provide easy access and pleasant 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 of SWD pupa
10. Reduced Bird Feeding: Allow for bird evacuation at open ends
# Exclusion Costs in PYO Raspberry

<table>
<thead>
<tr>
<th>SWD Exclusion / ATK System Costs</th>
<th>Costs</th>
<th>Quantity</th>
<th>Costs</th>
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</thead>
<tbody>
<tr>
<td>8' Posts</td>
<td>$9.80</td>
<td>6</td>
<td>$58.80</td>
</tr>
<tr>
<td>Netting</td>
<td>$732</td>
<td>5200sq.ft.</td>
<td>$732</td>
</tr>
<tr>
<td>High Tensile Wire</td>
<td>4000'/$90.00</td>
<td>1800</td>
<td>$40.50</td>
</tr>
<tr>
<td>30&quot; Ground Anchors</td>
<td>$6.00</td>
<td>10</td>
<td>$60.00</td>
</tr>
<tr>
<td>4' Ground Anchors</td>
<td>$10.00</td>
<td>6</td>
<td>$60.00</td>
</tr>
<tr>
<td>Bushings</td>
<td>$0.01</td>
<td>4</td>
<td>$0.04</td>
</tr>
<tr>
<td>Zip Ties</td>
<td>$0.03</td>
<td>100</td>
<td>$3.00</td>
</tr>
<tr>
<td>Ground Cloth</td>
<td>$0.67</td>
<td>3600sq.ft.</td>
<td>$240.00</td>
</tr>
<tr>
<td>Ground Cloth 6&quot; Staples</td>
<td>$0.11</td>
<td>120</td>
<td>$13.20</td>
</tr>
<tr>
<td>Rachet enasioners</td>
<td>$4.50</td>
<td>6</td>
<td>$27.00</td>
</tr>
<tr>
<td>Gripple Tensioners</td>
<td>$1.50</td>
<td>12</td>
<td>$18.00</td>
</tr>
<tr>
<td>End Post Cams</td>
<td>$2.18</td>
<td>4</td>
<td>$8.70</td>
</tr>
<tr>
<td>Tubing</td>
<td>$0.23</td>
<td>10</td>
<td>$2.29</td>
</tr>
<tr>
<td>Binder Clips</td>
<td>$0.11</td>
<td>200</td>
<td>$22.22</td>
</tr>
<tr>
<td>4' Ground Conduit</td>
<td>$0.75</td>
<td>6</td>
<td>$4.50</td>
</tr>
<tr>
<td>10' Net Support Conduit</td>
<td>$1.75</td>
<td>10</td>
<td>$17.50</td>
</tr>
<tr>
<td>10' Post Separator Conduit</td>
<td>$1.75</td>
<td>2</td>
<td>$3.50</td>
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<tr>
<td>90 plumbing elbows</td>
<td>$0.6</td>
<td>6</td>
<td>$3.60</td>
</tr>
<tr>
<td>Sandbags</td>
<td>0.496666667</td>
<td>90</td>
<td>$44.70</td>
</tr>
<tr>
<td>Total material &amp; labor costs</td>
<td></td>
<td></td>
<td>$1,359.55</td>
</tr>
</tbody>
</table>
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

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