Spotted Wing Drosophila management in high tunnels

Celeste Welty
Extension Entomologist
June 2016
Spotted wing drosophila

• New key pest of **berries**
  – Outdoors
  – High tunnels
• Concern in **tomatoes**?
  – Slight
Spotted wing Drosophila

- *Drosophila suzukii*

- Looks like common vinegar flies on overripe, fallen, decaying fruit

- The new species attacks healthy ripening fruit
Fruit injury by Spotted wing Drosophila

- raspberry
- blueberry
- strawberry
- grape
- cherry
- peach
Hosts

• **Early:** cherries
• **Mid:** raspberries, blueberries, blackberries, peach, plum
• **Late:** grapes, strawberry (ever-bearing), raspberries
Hosts: tomato?

- Study at Cornell by Zuefle & Loeb 2014
  - 15 varieties
  - Intact fruit & cracked fruit
  - Skin firmness
- Field collected:
  - 0% infested intact fruit
  - 4% infested cracked fruit
- In lab:
  - 12% infested intact fruit
  - 61% infested cracked fruit
- Remove cracked fruit
Figure 5. Average force (g) required to penetrate the skin of seventeen different tomato varieties, eight known wild hosts and 4 known cultivated fruit hosts of SWD. The solid red line indicates the average penetration force of all tomatoes.
Origin

• From Asia
• In Hawaii since 1980
• 2008: California
• 2009: Florida, Washington, Oregon
• 2010: Michigan, Carolinas, Utah
• 2011: Ohio (Van Wert County)
Ohio: SWD reports

- Most reports
  - Blackberries
  - Raspberries
- Some reports
  - Blueberries
  - Peaches
  - Grapes

Photo by Ed Show
SWD detections in Ohio

Trap network
Red: found
Green: not found
SWD status in Ohio

• Bad news
  – Widespread
  – Severe damage

• Good news
  – Under control if insecticide program used
**SWD Life Cycle**

- **Female lays 1-3 eggs/site**
- **20-30d**
- **12-72h**
- **Pupate inside or outside of fruit**
- **4-15d**
- **3rd Instar Larvae**
- **5-7d**
- **2nd Instar Larva**
- **1st Instar Larva**

8-16 days per 1 generation
SWD eggs

Egg being deposited by female fly

Egg left on surface of berry

Egg laid below surface of berry
When talking to customers about worms in fruit...

• Say “Larvae”!
• Do not say “Maggots”!
Monitoring spotted wing Drosophila

• Critical: is this pest present on farm?
• Use **bait traps** to monitor **adult** flies
• Use **salt test** to monitor **larvae** in fruit
Baits to trap adult flies?

• Attractants
  – Fermenting matter

• Differences?
  – Earliest catch?
  – Fewest non-targets?
Bait traps

• Apple cider vinegar (2012-13) + a drop of dish soap

• Fermenting bait (2014)
  • Yeast + sugar + flour + water
  • Float on vinegar

• Commercial bait (2015)
  by Trécé; over water + a drop soap

• Commercial bait (2016)
  by Scentry, over 25% vinegar + soap
Using traps in fruit crops

- Hang in canopy, near fruit clusters
- Holes facing outward
- On shady side
- 1-2 weeks prior to fruit ripening
Trap, then identify

• Threshold: a single SWD adult
• Need to separate:
  – Suspected SWD
  – All others
• Equipment:
  – Minimal: 30x magnifying lens
  – Better: Dissecting microscope
i.d. of adult male

- Spots on wings
- Spots can be absent on young (newly emerged) males
- 2 dark bands of combs on front leg
i.d. of adult female

- No spots on wings
- Saw-like ovipositor
  - Large, dark, more obvious

Photo by Eric LaGasa

Washington State University
Seasonal trends in SWD traps

• 1st catch mid-July at most sites
• 1st catch June at few sites
• Higher catch when cool & wet
• Lower catch when hot & dry
• Peak catch in Sept.-October
## SWD outreach: need for more?

<table>
<thead>
<tr>
<th>When?</th>
<th>What?</th>
<th>Where?</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 2013</td>
<td>workshop (3 hour)</td>
<td>Columbus</td>
</tr>
<tr>
<td>April 2014</td>
<td>workshop (3 hour)</td>
<td>Columbus</td>
</tr>
<tr>
<td>Early May 2015</td>
<td>webinar (1.5 hour)</td>
<td>-</td>
</tr>
<tr>
<td>Late May 2015</td>
<td>workshop (1.5 hour)</td>
<td>Wooster</td>
</tr>
<tr>
<td>April 2016</td>
<td>workshop (3 hour)</td>
<td>Wilmington</td>
</tr>
</tbody>
</table>
Test fruit for SWD larvae with salt test

- Get bag or jar
- Fill with warm water + salt
- Add fruit
- Examine top surface in 15 minutes
- Larvae will float
Salt test
## Salt test: proportions

<table>
<thead>
<tr>
<th>Salt</th>
<th>Warm water</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Tablespoon</td>
<td>1 cup</td>
</tr>
<tr>
<td>¹⁄₄ cup</td>
<td>1 quart (4 cups)</td>
</tr>
<tr>
<td>1 cup</td>
<td>1 gallon</td>
</tr>
</tbody>
</table>
## Approach to SWD Monitoring

<table>
<thead>
<tr>
<th>Time</th>
<th>Traps</th>
<th>Salt Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before 1(^{st}) SWD detected</td>
<td>Check weekly and sort sample within 24 hrs (5-10 min/trap) Report findings, even if 0</td>
<td>No Ripe fruit: No Test Ripe fruit: Test Optional</td>
</tr>
</tbody>
</table>
## Approach to SWD Monitoring

<table>
<thead>
<tr>
<th>Time</th>
<th>Traps</th>
<th>Salt Test</th>
</tr>
</thead>
</table>
| **Before 1\textsuperscript{st} SWD detected** | Check weekly and sort sample within 24 hrs (5-10 min/trap)  
Report findings, even if 0 | No Ripe fruit: No Test  
Ripe fruit: Test Optional |
| **After 1\textsuperscript{st} SWD detected**  | Optional: Check weekly, keep samples, no need to sort for SWD | **Weekly**, best 1-2 days prior to insecticide spray |
Biocontrol??

- Natives: ~2% parasitism
- Exploration in Korea
  - 4 parasitoid species
  - In quarantine @ Berkeley
Cultural controls for SWD

• Prompt harvest as soon as ripe

• Sanitation
  – Strongly recommended!
  – Destroy ALL leftover fruit
  – Do every 2 days
  – Culls in clear plastic bags in sun, 1 week
Cultural controls for SWD

• **Chill** fruit as soon as harvested
  – Kills eggs & young larvae
  – 8 days at 33 – 34 °F
Cultural controls for SWD

• Keep plant rows narrow
  – Berries easy to see & remove

• Open up canopy
  – Thin to 3 – 4 strong canes per ft$^2$
  – Trellis
  – Improved spray coverage
  – Makes picking easier

• Allow ground to dry before irrigating
### Cultural controls by crop & variety selection

<table>
<thead>
<tr>
<th>Grow this</th>
<th>Do not grow this</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early-ripening blueberry varieties</td>
<td>Late-ripening blueberry varieties</td>
</tr>
<tr>
<td>Summer raspberries</td>
<td>Fall raspberries</td>
</tr>
<tr>
<td>June bearing strawberries</td>
<td>Ever-bearing strawberries</td>
</tr>
<tr>
<td>Black raspberries</td>
<td>-</td>
</tr>
<tr>
<td>Thick-skin grapes</td>
<td>Thin-skin grapes</td>
</tr>
</tbody>
</table>
Cultural control by removal of nearby wild hosts

- Wild raspberry
- Wild blackberry
- Autumn olive
- Tartarian honeysuckle
- Bush honeysuckle
- Pokeweed
- Mock strawberry
- Silky dogwood
- Persimmon
- Rose hips
Mechanical control by netting

• Exclusion netting on outdoor crop
  – Also helps with birds & hail
• Netting added to high tunnels
Mechanical control by netting

- Can use row cover material
- Openings < 1 mm (18 mesh)
- Most using ProtekNet
  - 80 gram
  - 60 gram
- Can be ventilation issues

Dale Ila M. Riggs, 2014 (New York)
Mechanical control by netting

• On outdoor crop
• Feasible but takes planning
• Study in blueberry, NY
  – by Dale Ilia M. Riggs
  – Use existing bird net support system
  – Install after pollination
• Can add bee pollinators
Mechanical control by netting

• High tunnel studies
  – By Rufus Isaacs in MI
  – By Donn Johnson in AR
  – By Schattman & Link in VT
Insect Exclusion Netting for SWD Control

Heather Leach and Rufus Isaacs

Large doors allow tractor mounted sprayer

Small doors adequate for backpack sprayer
Insect Exclusion Netting for SWD Control
Heather Leach and Rufus Isaacs

- 3 high tunnels growing red raspberries covered in 80 gram netting
- Netting significantly delays and reduces SWD infestation
- Overall insect abundance decreased
- Increasing trends in temperature, but not significant
- No effect on fruit quality (brix, weight, diameter)

Large doors allow tractor mounted sprayer
Small doors adequate for backpack sprayer
Insect Exclusion Netting for SWD Control

Heather Leach and Rufus Isaacs
Insect Exclusion Netting for SWD Control
Heather Leach and Rufus Isaacs
Harvest Frequency for SWD Control
Heather Leach and Rufus Isaacs

- Plots harvested either every day, every 2 days, or every 3 days
- Increasing harvest frequency to every day or every other day can significantly lower the number of SWD larvae in fruit
- 1^{st} and 2^{nd} instars considered undetectable larvae, 3^{rd} instars considered detectable larvae
Insect Exclusion Netting for SWD Control
Heather Leach and Rufus Isaacs

Assumes 1 acre: 5 adjacent 400 x 25 ft tunnels
Door and side netting = Tek-Knit 80 gram (Berry Protection Solutions)

Lifespan about 7 years
Exclusion netting for control of spotted wing drosophila (SWD) in commercial blueberries and raspberries

Rachel Schattman & Hannah Link
Univ. of Vermont
Exclusion in high tunnels
Schattman & Link, Univ. of Vermont

Evaluated:
• ProtekNet 80
• ProtekNet 60
• a partial control (PN80)
• control
Results: Netting reduced total SWD population in raspberry high tunnels
Trellis Systems

Large net-box

Small net-box

Medium tunnel

Most important qualities of a netting system:
1. Labor efficiency and ability to mow between the rows.
2. Readily available material and expense.
Insecticide strategy for SWD control

When to start spraying?

• If the adult flies are detected
• Fruit is susceptible to injury once it has started to turn color
# Insecticide choices for SWD control

<table>
<thead>
<tr>
<th>Efficacy</th>
<th>Group</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Most effective</td>
<td>spinosyns</td>
<td>Delegate</td>
</tr>
<tr>
<td></td>
<td>diamides</td>
<td>Exirel</td>
</tr>
<tr>
<td></td>
<td>organo-phosphates</td>
<td>Imidan, Diazinon</td>
</tr>
<tr>
<td></td>
<td>pyrethroids</td>
<td>Mustang Max, Brigade, Pounce, Hero, Danitol, Baythroid, Asana, Warrior</td>
</tr>
<tr>
<td></td>
<td>carbamates</td>
<td>Lannate</td>
</tr>
<tr>
<td>Effective</td>
<td>organo-phosphates</td>
<td>Malathion</td>
</tr>
<tr>
<td></td>
<td>carbamates</td>
<td>Sevin</td>
</tr>
<tr>
<td></td>
<td>spinosyns</td>
<td>Entrust [OMRI]</td>
</tr>
<tr>
<td>Moderately</td>
<td>neonicotinoid</td>
<td>Assail, Actara, Provado</td>
</tr>
<tr>
<td>Slightly</td>
<td>pyrethrins</td>
<td>Pyganic [OMRI]</td>
</tr>
</tbody>
</table>
How often to spray?

When residues no longer active

<table>
<thead>
<tr>
<th>Product</th>
<th>Residual activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exirel</td>
<td>5 days</td>
</tr>
<tr>
<td>Delegate</td>
<td>5-7 days</td>
</tr>
<tr>
<td>Imidan, Diazinon</td>
<td>7 days</td>
</tr>
<tr>
<td>Pyrethroids:</td>
<td>7-10 days</td>
</tr>
<tr>
<td>Asana</td>
<td></td>
</tr>
<tr>
<td>Brigade</td>
<td></td>
</tr>
<tr>
<td>Danitol</td>
<td></td>
</tr>
<tr>
<td>Hero</td>
<td></td>
</tr>
<tr>
<td>Mustang Max</td>
<td></td>
</tr>
<tr>
<td>Warrior</td>
<td></td>
</tr>
<tr>
<td>Malathion</td>
<td>5-7 days</td>
</tr>
<tr>
<td>Lannate</td>
<td>3-6 days</td>
</tr>
<tr>
<td>Entrust</td>
<td>3-5 days</td>
</tr>
<tr>
<td>Pyganic</td>
<td>1-3 days</td>
</tr>
</tbody>
</table>
# Insecticides for SWD on Brambles

<table>
<thead>
<tr>
<th>Product</th>
<th>Pre-harvest interval</th>
<th>Maximum number of applications allowed (if used at max rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delegate</td>
<td>1 day</td>
<td>3</td>
</tr>
<tr>
<td>Mustang Max</td>
<td>1 day</td>
<td>6</td>
</tr>
<tr>
<td>Malathion</td>
<td>1 day</td>
<td>3</td>
</tr>
<tr>
<td>Entrust [OMRI]</td>
<td>1 day</td>
<td>4</td>
</tr>
<tr>
<td>Danitol</td>
<td>3 days</td>
<td>2</td>
</tr>
<tr>
<td>Brigade</td>
<td>3 days</td>
<td>2</td>
</tr>
<tr>
<td>Hero</td>
<td>3 days</td>
<td>2</td>
</tr>
<tr>
<td>Pyganic [OMRI]</td>
<td>0 days</td>
<td>-</td>
</tr>
</tbody>
</table>
New options for organic growers

• Grandevo
  – 2(ee) labels for SWD
    • Control on stone fruit
    • Suppression on bushberries
    • Suppression on caneberries
  – 3 lbs / acre

• Venerate
  – No 2(ee) labels for SWD
  – 4 – 8 qt/A
Grandevio® DF on Tart Cherry vs. Spotted Wing Drosophila and Cherry Fruit Fly

Number of pupae per pound of fruit at harvest
J. Wise, MSU 2013

# DFF per pound of fruit

- UTC
- Grandevo @ 3 lb
- Exirel 20.5 fl oz
- Endigo 6 fl oz

Partial treatment list, adjuvants included in applications.

Slide by Tim Johnson, Marrone Bio Innovations
Grandevio® DF on Tart Cherry vs. Spotted Wing Drosophila

Number of pupae per pound of fruit at harvest
J. Wise, MSU 2014

# DPF per pound of fruit

UTC  Grandevo @ 3 lb  Grandevo @ 2 lb  Imidan @ 2.125 lb  Exirel @ 16 fl oz

Partial treatment list, adjuvants included in applications.

Slide by Tim Johnson, Marrone Bio Innovations
Control of Spotted Wing Drosophila on Blackberry in Washington State

# SWD Larvae/140 Blackberry Fruit
(Sum of 7 Evaluations of 20 Fruit Each)

Six applications in 150 GPA, means separated by SNK (P=0.05) following data transformation. Trial conducted by Agricultural Development Group.
Sucrose adjuvant to increase efficacy
(Cowles et al. 2015)

- Add sucrose (sugar)
- Assume 50 gal water/acre
- Use 1 pound/acre
Summary: Management of SWD on brambles

1. Use **bait traps**, check weekly
2. If any SWD in traps, start spray program when berries start to color
   - Spray* until final harvest
3. Do a **salt test** with ripe fruit, weekly, to see if program effective
4. Spray more often if control not good

* every 7 days if conventional: Delegate & Mustang
* every 5 days if organic: Entrust & Pyganic, + sugar
# Chart for SWD on all crops

[Chart image]

<table>
<thead>
<tr>
<th>Efficacy</th>
<th>Mode of action group</th>
<th>Product</th>
<th>Residual activity (days)</th>
<th>Pre-harvest interval (PHI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>raspberry, blackberry, blueberry, strawberry, grape, cherry, peach, plum</td>
<td></td>
</tr>
<tr>
<td>Very effective</td>
<td>5</td>
<td>§ Delegate</td>
<td>5-7</td>
<td>1 day, 3 days, X, 7 days, 7 days, 14 days, 7 days</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>§ Radiant</td>
<td>X</td>
<td>X, 1 day, X, X, X, 3 days, 3 days, 3 days</td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>Exirel</td>
<td>5</td>
<td>X, 3 days, X, X, 3 days, 3 days, 3 days</td>
</tr>
<tr>
<td></td>
<td>3A</td>
<td>Mustang Max</td>
<td>7-10</td>
<td>1 day, 1 day, X, 1 day, 14 days, 14 days, 14 days</td>
</tr>
<tr>
<td></td>
<td>3A</td>
<td>Brigade</td>
<td>7-10</td>
<td>3 days, 1 day, X, X, 30 days, X, X</td>
</tr>
<tr>
<td></td>
<td>3A</td>
<td>Hero</td>
<td>7-10</td>
<td>3 days, 1 day, X, X, 30 days, X, X</td>
</tr>
<tr>
<td></td>
<td>3A</td>
<td>Danitol</td>
<td>7-10</td>
<td>3 days, 3 days, 2 days, 21 days, 3 days, 3 days, 3 days</td>
</tr>
<tr>
<td></td>
<td>3A</td>
<td>Asana</td>
<td>7-10</td>
<td>7 days, 14 days, X, X, 14 days, 14 days, 14 days</td>
</tr>
<tr>
<td></td>
<td>3A</td>
<td>Baythroid</td>
<td>7-10</td>
<td>7 days, 14 days, X, X, 3 days, 7 days, 7 days</td>
</tr>
<tr>
<td></td>
<td>3A</td>
<td>Warrior</td>
<td>7-10</td>
<td>7 days, 14 days, X, X, 3 days, 7 days, 7 days</td>
</tr>
<tr>
<td></td>
<td>3A</td>
<td>Pounce</td>
<td>7-10</td>
<td>X, X, X, X, X, X, X</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>Imidan</td>
<td>7</td>
<td>3 days, X, 14 days, 7 days, 14 days, 7 days</td>
</tr>
<tr>
<td></td>
<td>1B</td>
<td>§§ Diazinon</td>
<td>7</td>
<td>7 days, 7 days, 5 days, X, 21 days, 21 days, 21 days</td>
</tr>
<tr>
<td></td>
<td>1A</td>
<td>Lannate</td>
<td>3-6</td>
<td>3 days, 3 days, X, X, X, 4 days</td>
</tr>
<tr>
<td>Effective</td>
<td>1B</td>
<td>Malathion</td>
<td>5-7</td>
<td>1 day, 1 day, 3 days, 3 days, 3 days, 3 days, X</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Entrust [OMRI]</td>
<td>3-5</td>
<td>1 day, 3 days, 1 day, 7 days, 14 days, 14 days, 7 days</td>
</tr>
<tr>
<td>Moderately effective</td>
<td>1A</td>
<td>Sevin</td>
<td>10</td>
<td>7 days, 7 days, 7 days, 7 days, 3 days, 3 days, 3 days</td>
</tr>
<tr>
<td></td>
<td>4A</td>
<td>Assail</td>
<td>1-3</td>
<td>1 day, 1 day, 1 day, 3 days, 7 days, 7 days</td>
</tr>
<tr>
<td>Slightly eff.</td>
<td>3A</td>
<td>Pyganic [OMRI]</td>
<td>1-3</td>
<td>0 days, 0 days, 0 days, 0 days, 0 days, 0 days, 0 days</td>
</tr>
<tr>
<td>Not effective</td>
<td>4A</td>
<td>Actara</td>
<td>1-3</td>
<td>3 days, 3 days, X, 5 days, 14 days, 14 days, 14 days</td>
</tr>
<tr>
<td></td>
<td>4A</td>
<td>Admire Pro</td>
<td>1-3</td>
<td>3 days, 3 days, 7 days, 0 days, 7 days, 0 days, 7 days</td>
</tr>
</tbody>
</table>

- ! Restricted-Use Pesticide
- § Not allowed in greenhouses or high tunnels
- X means that the product is NOT ALLOWED for use on that crop.
Insecticides for high tunnels?

For products used for SWD control:

• **Label prohibits** in greenhouses:
  – Delegate
  – Diazinon

• **Label allows** in greenhouses:
  – Malathion

• **Label ‘silent’ on greenhouses therefore ok to use:**
  – pyrethroids: Asana, Baythroid, Brigade, Danitol, Hero, Mustang, Pounce, Warrior
  – Lannate
  – Imidan
  – Entrust
Additional info on SWD

On website:  u.osu.edu/pestmanagement
  • 2-page color info sheet
    – Includes insecticides for commercial farms
  • Instructions for trapping
  • Instructions for salt tests
  • Insecticide list for home gardens
  • Information about chilling fruit
  • Microscope recommendations
  • Slide show
  • Links to references
On-line resources

- Selecting tunnel structures & plastics
- Optimizing productivity & pest management
- Increasing profits
- Minimizing plastic waste generation
website: u.osu.edu/pestmanagement

 e-mail: welty.1@osu.edu

 office phone: 614-292-2803

 cell phone: 614-746-2429