IPM Techniques to Address the Invasive Spotted Wing Drosophila in Blueberries

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Overview

1. Blueberry Production in the Southeastern US
2. Introduction to SWD
3. Current Research
   - Oviposition Behavior
   - Florida Distribution
   - Monitoring
   - Chemical Control
4. IPM Recommendations
5. Future Research
Blueberry Production in the Southeast

- ~136,600,000 lbs (USDA-NASS 2011)
- Southeast produces 32% of U.S. total (USDA-NASS 2011)
Key Blueberry Pests in the Southeastern US

Early Season
- Blueberry Gall Midge
- Western Flower Thrips

Mid Season
- Cranberry Fruitworm
- Blueberry Maggot
- Spotted Wing Drosophila
SWD Global Distribution

- Japan 1916 – Identified by Matsumura in 1931
- Hawaii 1980 – first in US
- California 2008
- Washington & Oregon 2009
- European countries
- Other US states
- Florida 2009
SWD Records in the Southeastern US
Identification of SWD

- **Family**
  - Drosophilidae
  - “Vinegar flies”
  - “Fruit flies”
  - “Pomace flies”

- **Male**
  - Dark spots on wings
  - Two bands on forelegs

- **Female**
  - Serrated ovipositor
  - No wing spots

[Sources](http://extension.psu.edu/vegetable-fruit/fact-sheets/spotted-wing-drosophila)
SWD Lifecycle

Egg 1-3 days

Pupae 4-15 days

Adult 21-63 days*
Oviposition 1-2 days
Fecundity 200-600 eggs

Larvae 5-7 days
Host Injury

- Scars on berry upon insertion of the ovipositor
- Berry browns and softens as larvae develop inside
Key Small Fruit Hosts in the Southeast
What Areas of the State are Infested with SWD?

Monitoring for SWD
2012 SWD Distribution in FL

- 15 blueberry farms sampled in 9 counties
- 4 to 6 traps set at each location
- Traps serviced weekly for 4 to 11 weeks
  - February 14 to May 17
Trap Design

- Plastic cup with yellow visual stimulus and lid
- 8 to 10 holes along top
- 150 ml ACV
- 2 drops odorless dish soap
- Twist-tie
Mean SWD By County

County from North to South

Suwannee, Alachua, Putnam, Marion, Citrus, Lake, Orange, Polk, DeSoto

Mean SWD per Trap

P < 0.05
Mean Female And Male SWD By County

* $P < 0.05$
Distribution of SWD Findings

- SWD present in 8 of 9 major blueberry producing counties
  - Highest mean in Citrus

- Absence in DeSoto suggests higher temperatures early in the season may help prevent establishment

- Higher numbers of females in Alachua, Citrus, Orange, and Putnam suggest counting males may not provide accurate estimate of total SWD population
What is the Most Effective Trapping System for SWD?
## Comparison of Traps

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B(yel)</th>
<th>C(soap)</th>
<th>D(card)</th>
<th>Control</th>
</tr>
</thead>
</table>

- **Location:** Citrus County
- **RCBD with 4 replicates**
- **Traps serviced and rotated weekly**
Trap Study Results

Mean SWD per Trap

Mean Male and Female per Trap

Treatment

* $P < 0.05$
Trap Study Findings

- Control not recommended

- Visual lure, sticky card nor soap significantly affected SWD capture

- Generally more females
  - ACV more attractive to females?
  - Greater female to male ratio in field?
  - Is ACV most attractive bait?
What is the Most Effective Bait for SWD?

Monitoring for Adult SWD
Current and Future Baits

- **Current**
  - Apple Cider Vinegar
  - Yeast-Sugar Mixture
  - Fermented Fruit

- **New Possibilities**
  - Merlot + Rice Vinegar
  - Merlot + Red Wine Vinegar
    - Landolt et al. 2012
## Bait Study: ACV vs. Yeast-Sugar

### Treatments

<table>
<thead>
<tr>
<th>ACV</th>
<th>Yeast-sugar</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Soap, No YSI</td>
<td>No Soap, No YSI</td>
</tr>
<tr>
<td>No Soap, YSI</td>
<td>No Soap, YSI</td>
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</tr>
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</table>

YSI = yellow sticky insert
1. Sample >30 edible berries
2. Place in resealable plastic bag
3. Lightly crush berries
4. Add sugar/salt solution
5. Allow fruit to sink, 10-15 mins
6. Larvae will float to surface

¼ cup salt/sugar
4 cups water
Blueberry Maggot vs. SWD

- **Shape**
  - SWD tapered at both ends
  - BB Maggot tapered anterior, flattened posterior

- **Size**
  - Full-grown BB Maggot 2x full-grown SWD
  - May appear similar when young

http://ncsmallfruitsipm.blogspot.com/2012/02/larvae-in-fruit-distinguishing-between.html
How Effective Are Standard Labeled Pesticides Against SWD?

Control Techniques
## Chemical Techniques

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Type</th>
<th>PHI</th>
<th>Organic?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malathion</td>
<td>Organophosphate</td>
<td>1 day</td>
<td></td>
</tr>
<tr>
<td>Mustang Max</td>
<td>Pyrethroid</td>
<td>1 day</td>
<td></td>
</tr>
<tr>
<td>Danitol®</td>
<td>Pyrethroid</td>
<td>3 day</td>
<td></td>
</tr>
<tr>
<td>Delegate®</td>
<td>Spinosyn</td>
<td>3 day</td>
<td></td>
</tr>
<tr>
<td>Entrust</td>
<td>Spinosyn</td>
<td>3 day</td>
<td>Y</td>
</tr>
<tr>
<td>PyGanic</td>
<td>Pyrethroid</td>
<td>0 day</td>
<td>Y</td>
</tr>
</tbody>
</table>

Pesticides should be rotated with different modes of action to avoid resistance development.
Pesticide Efficacy Study

- Treatments sprayed in field with CO₂ backpack

- Treatments
  - Belay™ at 4 oz/ac
  - Belay™ at 6 oz/ac
  - Danitol® at 10.333 oz/ac
  - Danitol® at 16 oz/ac
  - Mustang® at 4 oz/ac
  - Delegate® at 6 oz/ac
  - Water treated control
Pesticide Efficacy Study

- Four branches selected from each treatment, placed in bioassay in lab 1, 3, 7, 14 days after application (DAA)
  - Uniform berry number
  - Range of ripeness stages

- 10 male and 10 female introduced into separate chambers
Adult Activity

- Measured daily for 72 h after flies introduced
- Observed for 5 mins
- Activity Scale:
  
  0  Fly death
  1  Response to tapping, inverted or twitching
  2  Decrease response to tapping
  3  Fly in its natural state, unaltered activity
# Response of Female SWD to Standard Pesticides

Average female adult activity per 24-h period for each treatment by DAA.

<table>
<thead>
<tr>
<th>Trt</th>
<th>Bel4</th>
<th>Bel6</th>
<th>Dan10.3</th>
<th>Dan16</th>
<th>Mus4</th>
<th>Del6</th>
<th>Cont</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Day 1</strong></td>
<td>2.57 ± 0.10</td>
<td>2.42 ± 0.05</td>
<td>1.82 ± 0.06*</td>
<td>1.70 ± 0.14*</td>
<td>1.73 ± 0.09*</td>
<td>1.00 ± 0.36*</td>
<td>2.72 ± 0.08</td>
</tr>
<tr>
<td><strong>Day 3</strong></td>
<td>2.37 ± 0.05</td>
<td>2.46 ± 0.13</td>
<td>2.18 ± 0.11*</td>
<td>2.23 ± 0.10*</td>
<td>2.04 ± 0.15*</td>
<td>2.42 ± 0.11</td>
<td>2.85 ± 0.14</td>
</tr>
<tr>
<td><strong>Day 7</strong></td>
<td>2.73 ± 0.04</td>
<td>2.72 ± 0.06</td>
<td>2.51 ± 0.08*</td>
<td>2.32 ± 0.10*</td>
<td>2.62 ± 0.07</td>
<td>2.51 ± 0.02*</td>
<td>2.87 ± 0.03</td>
</tr>
<tr>
<td><strong>Day 14</strong></td>
<td>2.87 ± 0.12</td>
<td>2.98 ± 0.07</td>
<td>2.79 ± 0.05</td>
<td>2.86 ± 0.05</td>
<td>2.56 ± 0.11*</td>
<td>2.64 ± 0.04</td>
<td>2.93 ± 0.11</td>
</tr>
</tbody>
</table>

Asterisk (*) and highlighting indicates significant difference when compared with the control as $P < 0.05$. 
**Response of Male SWD to Standard Pesticides**

Average male adult activity per 24-h period for each treatment by DAA

<table>
<thead>
<tr>
<th>Trt</th>
<th>Bel4</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>2.57 ± 0.11</td>
<td>2.33 ± 0.20</td>
<td>0.98 ± 0.32*</td>
<td>1.03 ± 0.11*</td>
<td>0.78 ± 0.14*</td>
<td>1.45 ± 0.19*</td>
<td>2.86 ± 0.08</td>
</tr>
<tr>
<td>Day 3</td>
<td>2.56 ± 0.05</td>
<td>2.41 ± 0.08</td>
<td>2.25 ± 0.26*</td>
<td>2.04 ± 0.26*</td>
<td>2.47 ± 0.03</td>
<td>2.12 ± 0.20*</td>
<td>2.79 ± 0.11</td>
</tr>
<tr>
<td>Day 7</td>
<td>2.68 ± 0.13</td>
<td>2.64 ± 0.09</td>
<td>2.03 ± 0.12*</td>
<td>2.27 ± 0.07</td>
<td>2.41 ± 0.07</td>
<td>2.78 ± 0.08</td>
<td>2.72 ± 0.03</td>
</tr>
<tr>
<td>Day 14</td>
<td>2.83 ± 0.05</td>
<td>--- **</td>
<td>2.74 ± 0.11</td>
<td>2.60 ± 0.05</td>
<td>2.42 ± 0.13</td>
<td>2.72 ± 0.09</td>
<td>2.99 ± 0.04</td>
</tr>
</tbody>
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**Bel6 (Day 14) all male flies lost due to freezing process.**
Which Pesticides Reduce Larval Survival to the Next Generation?

- Females removed 72 h after introduction
- Emerging flies counted daily for 48 h after females removed
- Data collection began when the first flies emerged
Larval Survival

Average number of emerging flies per berry by treatment for each DAA.

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<tr>
<th>Trt</th>
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<th>Cont</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day 1</td>
<td>0.37 ± 0.17</td>
<td>0.20 ± 0.07</td>
<td>0.08 ± 0.06*</td>
<td>0.01 ± 0.01*</td>
<td>0.17 ± 0.15</td>
<td>0.60 ± 0.52</td>
<td>1.36 ± 0.44</td>
</tr>
<tr>
<td>Day 3</td>
<td>0.49 ± 0.23</td>
<td>0.35 ± 0.13</td>
<td>0.26 ± 0.25</td>
<td>0.24 ± 0.21</td>
<td>0.21 ± 0.17</td>
<td>0.46 ± 0.22</td>
<td>0.26 ± 0.09</td>
</tr>
<tr>
<td>Day 7</td>
<td>2.35 ± 0.78</td>
<td>0.96 ± 0.73</td>
<td>0.38 ± 0.23</td>
<td>0.46 ± 0.33</td>
<td>0.76 ± 0.45</td>
<td>0.93 ± 0.34</td>
<td>1.21 ± 0.51</td>
</tr>
<tr>
<td>Day 14</td>
<td>2.91 ± 1.67</td>
<td>1.12 ± 0.54</td>
<td>0.44 ± 0.14</td>
<td>1.19 ± 0.95</td>
<td>0.66 ± 0.31</td>
<td>1.50 ± 0.60</td>
<td>2.52 ± 0.79</td>
</tr>
</tbody>
</table>

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Pesticide Efficacy Findings

- Danitol®, Mustang Max® and Delegate® performed equally well at reducing adult SWD activity
  - No differences between Danitol® 10 oz and 16 oz rates

- Danitol® appears to be effective in preventing SWD larval survival to the next generation

- Belay™ at 4 and 6 oz/acre were not effective in suppressing adult activity or larval survival throughout study
General IPM Recommendations

- Weekly monitoring using cup traps
  - ACV or yeast-sugar mixture bait
  - 1 trap per 5-acre block
  - Field borders and center of field

- Cultural Techniques
  - Sanitation
  - Frequent harvesting
  - Removal of culls

- Chemical control
  - Reduced-risk pesticides according to label rates
  - Rotate classes

Begin implementing management programs when berries are full green.
Future Research Considerations

- Evaluation of traps and lures (field and lab experiments)
- Reduced-risk and biological chemical controls
- Evaluation of sugar as a bait in pesticides
- Site characteristics effect on SWD population
Acknowledgements

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- Tamika Garrick
QUESTIONS?