Overview: What To Expect

- Introduction
- Western Flower Thrips
  - Why A Problem
  - Research
- Citrus Mealybug
  - Why A Problem
  - Research
- Questions and Discussion

Western Flower Thrips, *Frankliniella occidentalis*

**Adult**

**Larva**

Plant Damage

- Direct: feeding injury to leaves and flowers.
- Indirect: transmit the tospoviruses—*Impatiens necrotic spot virus* (INSV) and *Tomato spotted wilt virus* (TSWV).

Greenhouse Production System

Western Flower Thrips

- Life Cycle
  - Egg
  - Larvae (n=2)
  - Pupae (n=2)
  - Adult

Life Cycle Can Be Completed In 18 To 24 Days Depending On Temperature
Western Flower Thrips Adults And Larvae Feeding On Chrysanthemum Leaf

Western Flower Thrips Feeding Damage On Transvaal Daisy Flower

**Impatiens Necrotic Spot Virus**

Why Western Flower Thrips Are A Major Insect Pest Of Greenhouse-Grown Horticultural Crops

- High female reproductive capacity
- Broad host range
- Rapid life cycle
- Number of generations
- Resistance to insecticides
  - Virus vector
  - Feeding habit
  - Cryptic behavior
  - Small size

Western Flower Thrips Management: An Historical Perspective (1980-2018)

- Cultural and physical management practices have ‘generally’ not changed.
- Reliance on insecticides: what is currently available and future products.
- Issues related to resistance: rotation of insecticides based on mode of action.
- Management of western flower thrips involves an integrated approach.
Western Flower Thrips Life Cycle

* Egg
* Larvae (n=2)
* Pupae (n=2)
* Adult

Not All Life Stages Are Susceptible To Insecticide Applications

Insecticides Commercially-Available In USA Based On Entomopathogenic (Beneficial) Organisms (Fungi Or Bacteria)

- *Beauveria bassiana* Strain GHA (BotaniGard)
- *Isaria fumosoroseus* Strain FE 9901 (NoFly)
- *Isaria fumosorosea* Apopka Strain 97 (Ancora)
- *Metarhizium brunneum* (formerly *anisopliae*) Strain F52 (Met52)
- *Chromobacterium subtsugae* Strain PRAA4-1 (Grandvevo)

How Beneficial Fungi Kill Insect Hosts

Research At Kansas State University

* Determine the effects of incorporating entomopathogenic organisms (fungi and bacteria) into rotation programs designed to mitigate western flower thrips populations.

Treatments:
1. All insecticides (spinosad, pyridalyl, abamectin, and chlorfenapyr)
2. Insecticides plus one entomopathogenic fungus [*Metarhizium brunneum* (*anisopliae*)]
3. Insecticides plus one entomopathogenic fungus (*Beauveria bassiana*)
4. Insecticides plus one entomopathogenic organism (*Isaria fumosorosea*/*Chromobacterium subtsugae*)
5. All entomopathogenic organisms
6. Water control

Experiment: Effect Of Rotation Programs On Western Flower Thrips Populations: Cumulative Effect

Cost comparison

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Weeks</th>
<th>Total cost (100 gal applications)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 and 2</td>
<td>5</td>
<td>$654</td>
</tr>
<tr>
<td>3 and 4</td>
<td>6</td>
<td>$571 ($575)</td>
</tr>
<tr>
<td>5 and 6</td>
<td>7</td>
<td>$709 (+ $28)</td>
</tr>
<tr>
<td>7 and 8</td>
<td>8</td>
<td>$629 (+ $50)</td>
</tr>
</tbody>
</table>

Incorporating entomopathogenic organisms into rotation programs may also reduce pest management costs for greenhouse producers.
**Insidious Flower Bug (Orius insidiosus):**
Predator Of Western Flower Thrips

**Research: Effect Of Insecticides And Biological Control Agents On Western Flower Thrips Pupal Stages (Prepupae And Pupae)**

**Western Flower Thrips Life Cycle**
* Egg
* Larvae (n=2)
* Pupae (n=2)
* Adult

Pupal Stages (Prepupae And Pupae) Are Not Susceptible To Insecticides Or Biological Control Agents
What Does The Future Hold?
1. Due to the costs and regulations associated with registering new insecticides; very few new active ingredients will be introduced into the marketplace specifically for western flower thrips.
2. Greenhouse producers must implement a combination of management strategies to alleviate problems with western flower thrips.
3. Due to issues associated with insecticide resistance, greenhouse producers will likely consider using biological control against western flower thrips.
4. The global movement of plant material may possibly exacerbate problems with western flower thrips.
Mealybugs

* Feed within the vascular system removing plant fluids (=phloem feeder).
* Damage symptoms: leaf distortion, plant stunting and wilting.
* Produce copious amounts of honeydew.

Why Are Mealybugs A Problem?

- Located in very secluded (cryptic) habitats, which makes detection difficult and ability to obtain contact with insecticides a challenge.
- Early instar nymphs (crawlers) are hard to detect.
- Later instars and adults develop a protective waxy (hydrophobic) covering, which inhibits the effectiveness of contact insecticides.
- Mealybug females have high reproductive potential (can lay over 400 eggs).
- Broad host range—mealybugs feed on many different plant types.

Mealybugs Tend To Feed In Cryptic Habitats. Thus They Escape Exposure From Visual Observation, Spray Applications Of Insecticides, And Biological Control Agents

What Can You Do In This Situation?

Mealybug Life Cycle: Egg To Adult

25 To 60 Days

Mealybug Life Cycle: Egg To Adult

Target Life Stages Of Insecticides
Insecticides Are Primarily Used To Manage Mealybug Populations In Horticultural Crop Production Systems

### Contact Insecticides
- Acephate (Orthene)
- Acetamiprid (TriStar)
- Bifenthrin (Talstar)
- Chlorpyrifos (DuraGuard)
- Clarified hydrophobic extract of neem oil (Triact)
- Cyfluthrin (Decathlon)
- Mineral oil (Ultra-Pure Oil/SuffOil-X)
- Potassium salts of fatty acids (M-Pede)
- Pyrifluquinazon (Rycar)

### Insect Growth Regulators
- **Buprofezin (Talus):** Chitin Synthesis Inhibitor
- **Kinoprene (Enstar):** Juvenile Hormone Mimic

### How To Effectively Use Insecticides Against Mealybugs
1. **Timing:** apply insecticides when the most susceptible life stages of mealybugs are present.
2. **Coverage:** when applying (spraying) an insecticide, it is important to obtain thorough coverage of all plant parts, including: leaves, stems, and flowers.
3. **Frequency:** apply insecticides within timely intervals, which is dependent on the residual activity of a given insecticide. Always read the label for information associated with frequency of application.

### Graphical Data
- **Mean Percent Mortality:** % of Mealybug Mortality
- **Treatments:** Atrra™, Aria™, Rycar, Señor, Orthene
- **Application Rates:** 1.05 ml, 0.28 g
- **Number of Applications:** 1, 2, 3
Are Systemic Insecticides Effective Against Mealybugs?

<table>
<thead>
<tr>
<th>Active Ingredient</th>
<th>Water Solubility (ppm)</th>
<th>(mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imidacloprid (Marathon)</td>
<td>610 ppm</td>
<td>610 mg/L</td>
</tr>
<tr>
<td>Thiamethoxam (Flagship)</td>
<td>4,100 ppm</td>
<td>4,100 mg/L</td>
</tr>
<tr>
<td>Acetamiprid (TriStar)</td>
<td>2,950 ppm</td>
<td>2,950 mg/L</td>
</tr>
<tr>
<td>Dinotefuran (Safari)</td>
<td>39,830 ppm</td>
<td>39,830 mg/L</td>
</tr>
<tr>
<td>Clothianidin (Arena)*</td>
<td>327 ppm</td>
<td>327 mg/L</td>
</tr>
<tr>
<td>Flupyradifurone (Altus)</td>
<td>3,200 ppm</td>
<td>3,200 mg/L</td>
</tr>
<tr>
<td>Spirotetramat (Kontos)</td>
<td>29 ppm</td>
<td>29 mg/L</td>
</tr>
<tr>
<td>Acephate (Orthene)</td>
<td>790,000 ppm</td>
<td>790,000 mg/L</td>
</tr>
<tr>
<td>Azadirachtin (Azatrol)</td>
<td>250 ppm</td>
<td>250 mg/L</td>
</tr>
<tr>
<td>Flonicamid (Aria)</td>
<td>5,200 ppm</td>
<td>5,200 mg/L</td>
</tr>
<tr>
<td>Pyrethroids (Eavert)</td>
<td>290 ppm</td>
<td>290 mg/L</td>
</tr>
<tr>
<td>Cyantraniliprole (Mainspring)</td>
<td>14,200 ppm</td>
<td>14,200 mg/L</td>
</tr>
</tbody>
</table>

**Neonicotinoid Insecticides (Labeled Rate)**

- **T** = Thiamethoxam
- **I** = Imidacloprid
- **D** = Dinotefuran
- **W** = Water

**Neonicotinoid Insecticides (2X Label Rate)**

- **T** = Thiamethoxam
- **I** = Imidacloprid
- **D** = Dinotefuran
- **W** = Water

**Mortality <50%**
Mealybugs And Whiteflies Feeding On Poinsettia Leaf

Female Citrus Mealybugs Feeding On Plant Stem

Feeding Location: Neonicotinoid Insecticides (Label Rate)

Curative Application

Preventative Application

Preventative Application
**Mealybug Feeding Behavior**

- Although mealybugs feed in the phloem sieve tubes similar to aphids and whiteflies; they feed differently.
- Feeding involves variations in the number and length of time of intracellular punctures, intervals between the first phloem-ingestion periods, and stylet motility or movement during the phloem searching process.
- Does feeding behavior impact the ability of systemic insecticides to suppress citrus mealybug populations?

**Conclusion**

Under The Parameters Of Our Studies (e.g. Greenhouse-Grown Horticultural Crops); Systemic Insecticides Are Not Effective Against The Citrus Mealybug When Applied To The Growing Medium As A Drench Or Granule!

**Funding Sources**

* Fred C. Gloeckner Foundation
* Industry Groups
THE END

DONE!

The End

It's QUESTION TIME!!