Possible IPM approaches to pest management under HLB

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Key Features of IPM

- Regular monitoring
- Combination of control methods
- Minimizing harm to beneficials and the environment
- Deciding whether treatment is necessary after assessing the pest populations
The Economic Threshold
The difference between injury and damage

Injury
Physical or physiological losses of plants caused by pests:
Reduced leaf areas or photosynthesis

Damage
Economic losses of plants caused by pests:
Reduced yield or quality

Injury does not always cause damage
The relationship between injury and damage

Yield-Response Curve

tolerance/resistance

Yield potential

Yield ($)

Injury related to pest density

Damage
Figuring out the economics of pest control
The Economic Injury Level (EIL)

\[ C = V \times I \times D \times P \]

\[ EIL = P = \frac{C_{\text{ost}}}{V \times I \times D_{\text{amage}}} \]
The Economic Injury Level (EIL)

How EIL works

- Economic loss
- No economic loss

Control

Pest density

Time
The Economic Injury Level (EIL)

How EIL works

Pest density

Economic loss

No economic loss

Control

EIL

Time

Keep insect densities below the EIL
Problems with use of Economic Injury Level (EIL)

Graph showing the relationship between pest density, time, and the release of natural enemies to control pest levels below the Economic Injury Level (EIL).
Treatments: # of insecticide sprays:

Calendar applications: 10
0.2 ACP threshold: 4
0.7 ACP threshold: 2
No insecticide: 1

HLB was 80% and higher

Looked at ACP suppression and yield, calculating cost of ACP management
Cumulative ACP Adults in Stem Tap Samples

**Location 1**

- Highest yield in Monthly spray (Calendar)
- No difference in profit between Calendar and 0.2/tap

**Location 2**

- Highest yield in Monthly spray (Calendar)
- 0.2/tap—Highest profit
What's the best EIL for your situation?

How EIL works

- Economic loss
- No economic loss

EIL

Control

Time

Pest density

Keep insect densities below the EIL

0.2/tap?
Keeping ACP down seems to help yield
Challenging plants to infestation and pathogen under controlled conditions

Citrus plants cv Valencia

Challenged with:
1) CLas-infected or
2) Non-infected ACP

1. One-time inoculation
2. Pulsed inoculation (Periodic invasions)
3. Continuous inoculation (Constantly reproducing resident population)
Preventing a standing infestation with or without pathogen prolongs tree life.
2018 Nonreplicated trial: Fewest fruit per tree where psyllid numbers were highest

CLas titer in mature leaves

Adult insects per tree
Rotation schedules effectively suppress resistance; consequences of not rotating show up nearly immediately.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Selection 1</th>
<th>Selection 2</th>
<th>Selection 3</th>
<th>Selection 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotation 1</td>
<td>Mar 24, 2019</td>
<td>May 5, 2019</td>
<td>Jun 10, 2019</td>
<td>Jun 22, 2019</td>
</tr>
<tr>
<td></td>
<td>Apr 22, 2019</td>
<td>May 31, 2019</td>
<td>Jun 28, 2019</td>
<td>--------------------</td>
</tr>
<tr>
<td>Rotation 2</td>
<td>fenpropathrin</td>
<td>dimethoate</td>
<td>cyantrniliprole</td>
<td>imidacloprid</td>
</tr>
<tr>
<td>Rotation 3</td>
<td>thiamethoxam</td>
<td>clothianidin</td>
<td>thiamethoxam</td>
<td>imidacloprid</td>
</tr>
</tbody>
</table>
Things ‘get real’; fast!

We observed 200-500 fold resistance with 2 back-to-backs; ~2000 fold after 3 consecutive failures to rotate.
Once we start to see > 100 fold resistance in the lab, failures in the field are evident.

Some rotations emerging as superior in terms of population suppression and resistance management interaction.
Does order of the sequence matter?

<table>
<thead>
<tr>
<th>Treatment</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>September</th>
<th>October</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotation A</td>
<td>dimethoate</td>
<td>abamectin + thiamethoxam</td>
<td>fenpropathrin</td>
<td>diflubenzuron</td>
<td>imidacloprid</td>
</tr>
<tr>
<td>Rotation B</td>
<td>imidacloprid</td>
<td>fenpropathrin</td>
<td>abamectin + thiamethoxam</td>
<td>dimethoate</td>
<td>diflubenzuron</td>
</tr>
<tr>
<td>Rotation C</td>
<td>thiamethoxam</td>
<td>diflubenzuron</td>
<td>dimethoate</td>
<td>imidacloprid</td>
<td>fenpropathrin</td>
</tr>
</tbody>
</table>

**No**

fenpropathrin → dimethoate → cyantraniliprole → imidacloprid

IGR, Oil, Kaolin, butenolide
Kaolin: Non-toxic particle film; affects ACP ability to grasp/feed on leaves


It’s not full proof; as leaves grow surfaces become unprotected; like anything applied to foliage in FL, can wash off; does not prevent HLB. Nonetheless, several studies have indicated efficacy against ACP comparable to toxic poisons.
Reflective mulch to repel ACP
Summary: Ways to Lower ACP Control Costs and Resistance

1. Thresholds can guide spray frequency and reduce sprays
2. Target control to reduce ACP in flush
   - Preemptive sprays may be best
   - Don’t let a standing population linger
3. Use border sprays to control psyllids where they congregate and reduce sprays to whole block
   - Selective products for whole block sprays
   - Cheap products for border sprays
4. Conserve beneficials by eliminating unnecessary sprays
5. Rotate between at least 5 modes of action
6. Other techniques (mulches, kaolin, mesh, windbreaks) either available and more coming (attract-and-kill)