Pest Control of Citrus in Nurseries and Resistance Management

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What is resistance?
Treating repeatedly kills off the susceptible pests and leaves behind mostly resistant ones.
Often, the susceptible pests are more fit than the resistant ones and so if left alone they will increase in the population

- Produce more eggs
- Grow quicker
Two most important things you can do:
1. Change the chemical so that the resistant ones can’t survive
2. Treat as infrequently as possible so that you give the susceptible ones time to build back up
How do insects develop resistance?

• Change their behavior
• Change their cuticle so that the pesticide can’t penetrate
• Increase the number of enzymes they have in their system to detoxify the pesticide and maintain normal function
• Change the shape of their enzymes so that the pesticide can’t block them
Nerve Synapse

Acetylcholine
Enzyme Acetylcholine esterase

Nerve Synapse

Acetylcholine
Acetylcholine esterase

Organophosphate or Carbamate Insecticide

Nerve Synapse

Acetylcholine
One method of resistance: the insect makes more AchE.
Second method of resistance: the insect makes a different AchE (decreased target site sensitivity)
Citrus Nursery Pest Issues

Common pests
- Mites (two-spotted, citrus red mite)
- Citrus thrips
- Citrus Leafminer

Occasional Pests
- Caterpillars (leafrollers, cutworms)
- Katydid
- Aphids
- Whiteflies
- California red scale
- Brown soft scale
- Earwigs
- Snails/slugs
- Ants
Citrus Red Mite - stippling leaves

- Adult Female
- Male guarding a quiescent female
- Egg
- Larva (6 legs)
- Deutonymph
- Protonymph (8 legs)
Two-spotted spider mite - stippling leaves + webbing

- Keep plants irrigated and unstressed
- Space out the plants
- Overhead irrigation helps to reduce
- Apply miticides when populations are low
# Citrus Miticides

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Formulation</th>
<th>Chem grp</th>
<th>REI</th>
<th>Bearing</th>
<th>Non-bearing</th>
<th>Nurseries</th>
<th>Enclosed structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milbemectin</td>
<td>Ultiflora</td>
<td>6</td>
<td>12 h</td>
<td>No</td>
<td>Yes</td>
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<tr>
<td>Hexythiazox</td>
<td>Savey 50 DF</td>
<td>10A</td>
<td>12 h</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td></td>
<td>Onager</td>
<td></td>
<td></td>
<td>Yes</td>
<td>Yes*</td>
<td></td>
<td>NS</td>
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<tr>
<td></td>
<td>HexygonDF</td>
<td></td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Etoxazole</td>
<td>Zeal Miticide</td>
<td>10B</td>
<td>12 h</td>
<td>No</td>
<td>Yes</td>
<td>NS</td>
<td>NS</td>
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<tr>
<td></td>
<td>TetraSan 5 WDG</td>
<td></td>
<td></td>
<td>Yes</td>
<td>Yes*</td>
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<tr>
<td>Fenbutatin oxide</td>
<td>Vendex 50 WP¹</td>
<td>12B</td>
<td>48 h</td>
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<td>Yes</td>
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<tr>
<td>Propargite</td>
<td>Omite 30WS¹</td>
<td>12C</td>
<td>16 d</td>
<td>No</td>
<td>Yes</td>
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<td>NS</td>
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<tr>
<td></td>
<td>Omite 6E¹</td>
<td></td>
<td></td>
<td>Yes</td>
<td>Yes*</td>
<td></td>
<td>NS</td>
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<tr>
<td>Acequinocyl</td>
<td>Kanemite 15 SC</td>
<td>20B</td>
<td>12 h</td>
<td>Yes</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Pyridaben</td>
<td>Nexter</td>
<td>21A</td>
<td>12 h</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Fenpyroximate</td>
<td>FujiMite 5 EC</td>
<td>21A</td>
<td>12 h</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
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<tr>
<td>Spirodiclofen</td>
<td>Envidor 2 SC</td>
<td>23</td>
<td>12 h</td>
<td>Yes</td>
<td>NS</td>
<td>NS</td>
<td>No</td>
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<tr>
<td>Spiromesifen</td>
<td>Judo</td>
<td>23</td>
<td>12 h</td>
<td>No</td>
<td>Yes*</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Bifenazate</td>
<td>Acramite 50 WS</td>
<td>un</td>
<td>12 h</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>NS</td>
</tr>
</tbody>
</table>

*nonbearing fruit trees – citrus not specified
¹ Cat I: certified applicator required
NS: not specified

Available chemical groups:
- 6 for non-bearing
- 5 for nursery
- 3 for enclosed structures
Citrus thrips – stunting and curling of leaves

• Lay their eggs in the leaf tissue and produce many generations per year
• Develop resistance very rapidly: DDT, Organophosphates, carbamates, pyrethroids
• No new chemicals for control
How do I control citrus thrips?

1. Rotate chemicals: Resistance and label restrictions for nurseries make this difficult

1. Spray as infrequently as possible

   • Keep plants well-irrigated and unstressed
   • Be careful not to over-fertilize as this may stimulate thrips populations
   • Overhead irrigation helps to reduce thrips by increasing humidity
   • Spray only when thrips are actually present, but at fairly low densities
Citrus Leafminer, stunting and curling of leaves
We are one of the last citrus growing regions on earth to be invaded by citrus leafminer.
CLM per leaf

8 DAT 24 DAT 33 DAT 41 DAT 52 DAT 65 DAT

water  oil  Altacor  cyazypyr  AgriMek SC  Agmectin+oil
Unsightly plants
Pest free plant material
4 Pheromone lures in a room such as this reduced egg laying by 50-70% and adding an oil treatment reduced their numbers even further.

<table>
<thead>
<tr>
<th>Leafminer per pot</th>
<th>Pheromone</th>
<th>No pheromone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>0.17</td>
<td>0.28</td>
</tr>
<tr>
<td>No oil</td>
<td>0.55</td>
<td>1.08</td>
</tr>
</tbody>
</table>

ISCA Lures
SPLAT CLM Pheromone confusion

Mean Larvae per plant

- Untreated
- SPLAT 1
- SPLAT 2

SPLAT per Plant

1/plant vs. 1/13 plants
How do I control citrus leafminer?

1. **Rotate chemicals: Resistance and label restrictions for nurseries make this difficult**

1. **Spray as infrequently as possible**
   - Be careful not to over-prune as new flush provides a home for leafminer
   - Reduce treatments in the winter in cool situations when activity is low
   - Use low rate oil treatments every 10-14 days instead of an insecticide
   - Experiment with pheromone lures
Treatments for pest quarantine

Asian citrus psyllid, *Diaphorina citri*
Imported fire ant, *Solenopsis invicta*
Glassy-winged sharpshooter, *Homalodisca vitripennis*
Diaprepes root weevil, *Diaprepes abbreviatus*
Eggs and nymphs on young flush

Adults on any leaves
Asian Citrus Psyllid and Huanglongbing (HLB)
HLB causes yellowing of leaves, odd fruit shape, color and size and bitter juice
Thin, unproductive trees with bitter juice and fruit that falls off easily
Trees can die in as little as 5 years
HLB Update

HLB in Hacienda Heights California
1 tree in a backyard Mar 2012

HLB in Hidalgo Texas
9 trees in two orchards Jan 2012

2 years to appear in Mexico and spread to the west coast
How did the psyllid and HLB spread through Florida?

The psyllid was first detected in backyard citrus trees in south Florida in 1998. The psyllid moved very rapidly both by flying (pink areas) as well as riding on nursery plants moved between retail nurseries throughout the state.

In retail nurseries, orange jasmine (*Murraya paniculata*) was a common host.
Psyllid Control Program

ACP was first discovered in California in 2008.
Treatments have kept it contained for 3 years.

Urban program

Pyrethroid: foliar cyfluthrin (Tempo)
Neonicotinoid: systemic imidacloprid (Merit)
# Nursery Quarantine Treatments for ACP

One foliar and one systemic required to move within the ACP quarantine area

<table>
<thead>
<tr>
<th>Class</th>
<th>Insecticide</th>
<th>Bearing</th>
<th>Non-bearing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Systemic</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neonicotinoid</td>
<td>Imidaclorpid</td>
<td>Admire Pro, Macho, Nuprid, Alias, Advise, Couraze, Widow</td>
<td>Merit, CoreTect Marathon II</td>
</tr>
<tr>
<td>Neonicotinoid</td>
<td>Thiamethoxam</td>
<td></td>
<td>Flagship</td>
</tr>
<tr>
<td>Neonicotinoid</td>
<td>Dinotefuran</td>
<td></td>
<td>Safari</td>
</tr>
<tr>
<td><strong>Foliar</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pyrethroid</td>
<td>Cyfluthrin</td>
<td>Baythroid</td>
<td>Tempo</td>
</tr>
<tr>
<td>Pyrethroid</td>
<td>Fenpropathrin</td>
<td>Danitoll</td>
<td>Tame, Decathlon</td>
</tr>
<tr>
<td>Pyrethroid + neonicotinoid</td>
<td>Cyfluthrin + imidaclorpid</td>
<td></td>
<td>Discus^</td>
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<tr>
<td>Organophosphate</td>
<td>Chlorpyrifos</td>
<td>Lorsban, Warhawk Quali-Pro Chlorpyrifos</td>
<td></td>
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<tr>
<td>Carbamate</td>
<td>Carbaryl</td>
<td>Sevin</td>
<td>Sevin</td>
</tr>
<tr>
<td>Tetronic acid</td>
<td>Spirotetramat</td>
<td>Movento^</td>
<td>Kontos</td>
</tr>
</tbody>
</table>

^No GH

http://www.cdfa.ca.gov/phpps/acp/quarantine.html
Issue 1: Treating plant material for quarantine pests
(Preparing for shipment)

Issue 2: How to manage existing pests in enclosed structures
(transition from primarily outdoor plantings to indoors)

Regulatory response to Asian citrus psyllid and huanglongbing disease

January 1, 2012: Registered mother trees under screen

January 1, 2013: Increase trees under screen

When HLB arrives: Production trees under screen
Lindcove screenhouses and positive pressure greenhouse
# Pest Quarantine Treatments

<table>
<thead>
<tr>
<th>Formulation</th>
<th>Glassy-winged Sharpshooter</th>
<th>Asian citrus psyllid</th>
<th>California red scale</th>
<th>Diaprepes Root weevil</th>
<th>Imported Fire ant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyrethroids-foliar</td>
<td>Eggs/nymphs, Adults</td>
<td>+++</td>
<td>++</td>
<td>Adults</td>
<td></td>
</tr>
<tr>
<td>Pyrethroid – soil (Talstar)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Larvae</td>
<td>+++</td>
</tr>
<tr>
<td>Neonicotinoids systemic</td>
<td>Eggs/nymphs, Adults</td>
<td>++</td>
<td>-</td>
<td>Adults</td>
<td></td>
</tr>
<tr>
<td>Neonicotinoids foliar</td>
<td>Adults</td>
<td>+++ (except Assail)</td>
<td>-</td>
<td>Adults</td>
<td></td>
</tr>
<tr>
<td>Organophosphates</td>
<td>+</td>
<td>++</td>
<td>+++</td>
<td>Adults</td>
<td></td>
</tr>
<tr>
<td>Carbamates</td>
<td>Egg/Nymphs</td>
<td>+</td>
<td>+</td>
<td>Adults</td>
<td></td>
</tr>
</tbody>
</table>

**Issues:**
- Quarantine pests are best controlled with long-lasting broad spectrum insecticides.
- Most insecticides have maximum label rates per season or year. If you reach the limit during the year for endemic pests, then you can not use them to treat for quarantine pests.