Know Mode of Action Groups to Manage Insecticide Resistance in the Florida Landscape

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Today we shall learn:

• What is resistance
• That insecticide Active Ingredients (AIs) have Modes of Action (MoA)
• That understanding MoA and managing can reduce resistance
• How to identify MoA
• How to make an insect control plan based on MoA
This is how resistance happens:

- Populations have a very few that are tolerant to the insecticide
- The insecticide kills others
- Survivors breed tolerant offspring
- Overuse creates population with many tolerant to the insecticide
So resistance is ...

• a change from a susceptible population to a tolerant one.
• caused by breeding among survivors.
• driven by repeated use of the same MoA.
Mode of Action (MoA) is a chemical action that disrupts a specific life process.

Example: Moth larvae outgrow their “skin” and make a new one. MoA group 15 (inhibitors of chitin synthesis) prevent new skin formation.
For ornamentals in Florida there are:

- About 200 insecticide trade marked products
- About 63 Active ingredients (AIs)
- About 23 MoA groupings
To delay resistance get rid of resistant genes:

- Include other control methods (cultural, biological, etc.)
- Rotate insecticide Modes of Action (MoA)
Rotation plan:

- Observe label restrictions
- Can repeat use of the same MoA group up to 1 life cycle
- Rotate through 3 or more MoA groups
How does an applicator know the MoA group of an insecticide?

- Sometimes indicated on label
- See: http://edis.ifas.ufl.edu/IN714
- Read label active ingredient (AI) then go to http://www.irac-online.org/Crop_Protection/MoA.asp and select “MoA Classification Scheme”
Rotation Methods

“Drawers of similar MoA insecticides” rotation method
MoA group 1A & 1B, Acetylcholinesterase inhibitor (nerve action):

- carbaryl (Sevin)
- methiocarb (Mesurol)
- acephate (Orthene, etc.)

more …
more MoA group 1A & 1B, Acetylcholinesterase inhibitors:

- chlorpyrifos (Dursban)
- malathion (Malathion)
- naled (Dibrom)

(more ...)
More MoA group 1A & 1B, Acetylcholinesterase inhibitors:

- oxydemeton-methyl (MSR)
- phosmet (Imidan)
- trichlorfon (Dylox)
MoA group 3A, Sodium channel modulators (nerve action):

- bifenthrin (Talstar)
- cyfluthrin (Decathlon, Tempo)
- cypermethrin (Demon)
- deltamethrin (Deltaguard)
- fenpropathrin (Tame)

(more ...)
More MoA group 3A, Sodium channel modulators:

- lambda-cyhalothrin (Scimitar, etc.)
- permethrin (Astro, etc.)
- \textit{tau}-Fluvalinate (Mavrik)
- pyrethrins (PyGanic, Pyreth-Lt, etc.)
MoA group 4A, Nicotinic acetylcholine receptor agonists (nerve action):

- imidacloprid (Merit, etc.)
- clothianidin (Arena, Celero)
- acetamiprid (TriStar)
- dinotefuran (Safari)
- thiamethoxam (Meridian)
MoA group 7A, 7B & 7C, Juvenile hormone mimics (growth regulation):

- 7A  s-methoprene (Extinguish)
- 7B  fenoxycarb (Award)
- 7C  pyriproxyfen (Distance)
MoA group 9B & 9C, Selective homopteran feeding blockers:

- 9B  pymetrozine (Endeavor)
- 9C  flonicamid (Aria)
MoA group 10A & 10B, Mite growth inhibitors (growth regulation):

- 10A hexythiazox (Hexygon)
- 10B etoxazole (Tetrasan)
MoA group 18, Ecdysone receptor agonists (growth regulation):

- tebufenozide (Mimic)
- halofenozide (Mach 2)
MoA group 20A & 20B, Mitochondrial complex III electron transport inhibitors (energy metabolism):

- 20A hydramethylnon (Amdro)
- 20B acequinocyl (Shuttle)
Each of the following AIs is alone in its MoA group.

EACH can be used in the same plan! (Each gets its own “drawer”)
MoA group 2B, GABA-gated chloride channel antagonists (nerve action):

- fipronil (Chipco Choice, etc.)
MoA group 5, Nicotinic acetylcholine receptor allosteric activators (nerve action):

• spinosad (Conserve, Justice)
MoA group 6, Chloride channel activators (nerve and muscle action):

- abamectin (Avid, Lucid)
MoA group 11, Microbial disruptors of insect midgut membranes:

- *Bacillus thuringiensis* and its sub-species
MoA group 12B, Inhibitors of mitochondrial ATP synthase (energy metabolism):

• fenbutatin-oxide (ProMite)
MoA group 15, Inhibitors of chitin biosynthesis type 0 (growth regulation):

- diflubenzuron (Dimilin)
MoA group 16, Inhibitors of chitin biosynthesis type 1 (growth regulation):

• buprofezin (Talus)
MoA group 17, Moulting disruptor, dipteran (growth regulation):

- cyromazine (Citation)
MoA group 22A, Voltage dependent sodium channel blockers (nerve action):

• indoxacarb (Advion, Provaunt)
MoA group 23,
Inhibitors of acetyl CoA carboxylase (lipid synthesis, growth regulation):

• spiromesiflen (Forbid)
MoA group 28, Ryanodine receptor modulators (nerve & muscle action):

- chlorantraniliprole (Acelepryn)
MoA group un, compounds of unknown or uncertain mode of action (separate drawers ?):

- azadirachtin (Azatin, Ornazin, etc.)
- bifenazate (Floramite)
- cryolite (Kryocide)
- dicofol (Kelthane)
But some do not need a MoA group code …

No code:

- *Beauveria bassiana* (Naturalis, Botanigard)
- metaldehyde (Deadline, Trails End)
- neem oil (Triact)
- petroleum oils (PureSpray Green, Ultra-Fine oil, etc.)
- soaps (DES-X, M-Pede)
- *Steinernema* spp. – nematodes (BioVector, Millenium, Nematac)
Example of a rotation plan for chili thrips:

5   spinosad -- Conserve
1B  acephate -- Orthene
3A  cyfluthrin -- Decathlon
4A  acetamiprid -- Tristar
4A  imidacloprid -- Merit
4A  dinoteefuran -- Safari
6   abamectin -- Avid
9C  flonicamid -- Aria
Summary:

- Resistance is from overuse of an insecticide MoA
- Delay resistance by using all control methods and rotating among MoA
- MoA listed at
  
  http://www.irac-online.org/
  Crop_Protection/MoA.asp
  (look for “MoA Classification Scheme”)

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Phytotoxicity Red Flags among Ornamental Insecticides
Some Common Phytotoxicity Manifestations:

- Leaf/petal/bract specking, spotting, necrosis
- Leaf/petal/bract marginal “burn”
- Leaf blade/bract thickening
- Leaf blade/bract “crinkling”
- Leaf blade loss of shine
- Stem internode length reduction
- Dead plant
Learn from pesticide labels
(Labels are your friends!)
“Red Flag” these:

- Oils
- Sulfur, sulfur containing compounds

(... more to flag in a moment ...)
### Some Stated Pesticide Cautions with Oil:
(Many with “hidden sulfur”):

<table>
<thead>
<tr>
<th>Left Column</th>
<th>Right Column</th>
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<tbody>
<tr>
<td>Dimethoate</td>
<td>Methiocarb</td>
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<tr>
<td>Propargite</td>
<td>Captan</td>
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<tr>
<td>Folpet</td>
<td>Dyrene</td>
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<tr>
<td>Oxythioquinox</td>
<td>Dinitro compounds</td>
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<td>Organotin compounds</td>
<td>Sulfur</td>
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<tr>
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<td>Dichloran</td>
<td>Dicofol</td>
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<tr>
<td>Dinocap</td>
<td>Permethrin</td>
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</tbody>
</table>
Oils Too May Be “Hidden” in Pesticides:

- Condor OF *B.t.* insecticide
- Certain high petroleum EC formulations
... (More to “Red Flag”):

- Soaps (see many cautions on label)
- Poinsettia bracts
- Flower petals
- Ferns
- Orthene
- High temperatures (>80°F)
- Drought stress, other stress
Consolidated Red Flag List:

- Oils
- Sulfur, sulfur containing compounds
- Soaps (see many cautions on label)
- Poinsettia bracts
- Flower petals
- Ferns
- Orthene
- High temperatures (>80°F)
- Drought stress, other stress
Some Pesticide Formulations Are Poorly compatible/incompatible with Others

Mix the WALE way

In the Diluent, add:

Wettable Powders and Water Dispersible Granules

Agitate

Liquids, Surfactants and Flowables

Emulsifiable Concentrates

(Search EDIS for “Pesticide Mixing”)
Reduce Phytotoxicity:

- Know Red Flag Situations
- Refer to Pesticide Labels
  (Google, then bookmark: “Florida Pesticide Information Retrieval System” and “CDMS labels”)
- Mix the WALE way