Resistance Management In Greenhouse Food Crops

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Overview: What To Expect

- Introduction
- Resistance
- Biological factors that promote resistance
- Why is resistance a problem in greenhouse food crops?
- Mode of action and rotation programs
- Ways to avoid pesticide resistance
- Questions and discussion
The Primary Means Of Dealing With Insect And Mite Pests In Horticultural Food Crop Production Systems Is The Use Of Pesticides (Insecticides And Miticides).
Resistance

- Resistance is the genetic ability of some individuals in an arthropod (insect or mite) pest population to survive an application or applications of pesticides (insecticides or miticides). In other words, the pesticide(s) no longer effectively kills a substantial number of individuals in the arthropod pest population.
Why Should We Be Concerned?

• Over 526 insect (and mite) species have developed resistance to pesticides over the last 50 years.

• Insects and mites will survive as they possess the inherent ability to evolve (or adapt) to various environmental and human disturbance factors (pesticides).
<table>
<thead>
<tr>
<th>Pest Species</th>
<th>1980’s</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Aphis gossypii</em></td>
<td>30</td>
</tr>
<tr>
<td><em>Myzus persicae</em></td>
<td>68</td>
</tr>
<tr>
<td><em>Bemisia spp.</em></td>
<td>33</td>
</tr>
<tr>
<td><em>Tetranychus urticae</em></td>
<td>72</td>
</tr>
<tr>
<td><em>Frankliniella occidentalis</em></td>
<td>13</td>
</tr>
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*Database of Arthropod Resistance to Pesticides*
Resistance

- **Resistance** develops at the population level and is an inherited trait. Surviving arthropod pests can pass traits (genetically) onto their offspring (young) or next generation thus enriching the gene pool with resistant genes.

- **Resistance indicates a change in the genetic composition of an arthropod pest population in response to selection by a pesticide (insecticide or miticide) over time.**
Resistance

• The amount of “selection pressure” or frequency in which insecticides and/or miticides are applied is the main factor that influences the ability of an arthropod pest population to develop resistance to insecticides or miticides.

• No insecticide or miticide is “resistant proof.”
OK...There Are Exceptions!
“Selection Pressure” Placed on Arthropod Pest Population: Influences Speed Of Resistance
Pesticide Application
How Resistance Develops In An Insect And Mite Population When Exposed To Pesticides (Insecticides And Miticides)
Resistance Development

Frequency of Resistant Individuals = 4%

Frequency of Resistant Individuals = 20%

Miticide Treatment

One Generation (8-14 days)
Resistance Development

Frequency of Resistant Individuals = 20% 

Frequency of Resistant Individuals = 63%
Resistance Development

Frequency of Resistant Individuals = 63%
Resistance

• “Selection pressure” for resistance increases as application frequency increases. Especially when insecticides and miticides with the same mode of action are applied in succession.

• The frequency in which resistant genes occur in a pest population determines the rate that resistance may develop.
Mechanisms Of Resistance

- Metabolic Resistance
- Physiological Resistance
- Physical Resistance
- Behavioral Resistance
- Natural Resistance
Metabolic Resistance

- Degradation of the active ingredient by an arthropod pest. When the pesticide enters the body, enzymes attack and **detoxify or convert the material into a non-toxic form**. The active ingredient is then excreted out with other waste products. **Metabolism is the most common resistance mechanism that occurs in insects.**
Example: Excreted Out With Other Waste Products.
Physiological Resistance

• An arthropod pest modifies the target site of the pesticide, which decreases sensitivity to the active ingredient at the physical point of attack because the target site has been altered.
Types Of Resistance

1. **Cross Resistance**: based on a single resistance mechanism conferring resistance to pesticides in the same chemical class and/or having similar modes of action.

2. **Multiple Resistance**: insect or mite pest population resistant to more than one pesticide by means of multiple resistance mechanisms.
Biological Factors Responsible For Promoting Resistance In Insect And Mite Pest Populations

• Short generation time.
• High reproductive rate.
• Wide host range.

• Haplo-diploid (arrhenotoky) breeding system: male only has one set of chromosomes (haploid), so any new genetic features (arising from mutations) will be immediately expressed (fixed); consequently increasing the potential for resistance developing.
Reproductive Capacity Of Certain Insect And Mite Pests Impacts The Ability Of These Insect And Mite Pests To Develop Resistance To Pesticides: “Numbers Game”

Aphid

Twospotted Spider Mites
Localized Or Isolated Insect/Mite Pest Populations May Develop Resistance Faster Than Insect/Mite Pests That Are More Mobile. Why? Intensive “Selection Pressure” And Reduction In The Number Of Susceptible Individuals That Can Breed With Resistant Individuals
Why Is Resistance So Problematic In Greenhouses?

* Environmental conditions such as temperature, light, and relative humidity are conducive for development and reproduction of insect and mite pests.

* Constant exposure to insecticides/miticides results in intense selection for resistance: especially products with extended persistence (residual activity).

* Enclosed environments limit immigration of susceptible individuals; thus resulting in a “high” proportion of resistant individuals in the population.
Application Factors That Influence Resistance

1. Timing
2. Frequency
3. Rate
4. Targeted Life Stage
Failure To Control Or Manage Insect Or Mite Pest Populations Is Not Always Due To Resistance!
Why Pesticides Fail To Suppress Insect And/Or Mite Pest Populations (Before Blaming Resistance)

1. Not using correct pesticide (e.g. insecticide or miticide).
2. Not using correct label rate.
3. Not thoroughly covering all plant parts with spray solution.
4. Watering heavily after applying a systemic insecticide: leaching material from the growing medium.
5. Not adjusting the pH of the spray solution.
6. Applying pesticides when susceptible life stages (e.g. larvae, nymphs, and adults) are absent/not present.
7. Not applying pesticides frequently enough; especially during spring through fall. Also, when dealing with multiple or over-lapping generations (with different age structures).
8. Not routinely scouting crop to determine the effectiveness of the pesticide application.
Mode Of Action And Pesticide Rotation
Mode Of Action

- How a pesticide such as an insecticide or miticide affects the metabolic and physiological processes in an insect or mite pest.
Narrow-Spectrum vs. Broad-Spectrum Mode Of Action Pesticides

- **Narrow-Spectrum (site-specific) Modes of Action:**
  - Pesticides that are active on specific target sites such as the central nervous system or enzymes associated with metabolism.

- **Broad-Spectrum Modes of Action:**
  - Pesticides that are active on a variety of target sites or possess multiple modes of action. These include: insecticidal soap, horticultural oils, selective feeding blockers, micro-organisms, and entomopathogenic fungi and bacteria.
Insecticide And Miticide Mode Of Action Makes A Difference

Rotation of products having different modes of action can prevent the development of resistant pests.

Pyrethroid
Chlorinated hydrocarbon
Destabilizes nerve cell membranes.

Organophosphate
Carbamate
Inhibits cholinesterase, prevents the termination of nerve impulse transmission.

Abamectin
Affects GABA-dependent chloride ion channel, inhibiting nerve transmission.

Growth Regulators
(Chitin synthesis inhibitors and juvenoids)

Soap and oil
Damages the waxy layer of the exoskeleton of soft bodied insects, resulting in suffocation.

Pyridazinone (SANMITE)
Mitochondrial electron transport inhibitor (METI) blocks respiration within the insect cell.
Target Site Of Insecticides And Miticides

Example of products that affect:

<table>
<thead>
<tr>
<th>Channel/Receptor</th>
<th>Insecticides and Miticides</th>
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<tbody>
<tr>
<td>Na⁺ channel</td>
<td>Pyrethroids, DDT</td>
</tr>
<tr>
<td>AChE</td>
<td>Organophosphates, Carbamates</td>
</tr>
<tr>
<td>Nicotinic ACh Receptor</td>
<td>Imidacloprid, Thiamethoxam</td>
</tr>
<tr>
<td>GABA Receptor</td>
<td>Avermectin, Fipronil, Cyclodienes</td>
</tr>
<tr>
<td>Unique Target Site</td>
<td>Spinetoram, Spinosad</td>
</tr>
</tbody>
</table>
NERVOUS SYSTEM

Pyrethroids

Axon

NA+ and CL- channels

ACh and AChE

Synapse

Dendrites
Receptors

Organophosphates And Carbamates
The primary (and best) way to alleviate insect and mite pest populations from developing resistance is to rotate insecticides and miticides with different modes of action!
The Rotation Of Insecticides
Assumes That The Frequency
Of Individuals Resistant To
One Insecticide Will Decrease
During The Application Of
Another Insecticide—With A
Different Mode Of Action.
Fig. 6. Diagrammatic representation of expected oscillations in susceptibility of a population that is exposed to 4 unrelated chemicals (A–D) used in rotation against succeeding generations (1–12).
Rotation Guidelines

- Rotate common names or active ingredients: not trade names.
- In general, rotate different modes of activity: 1) every one to two weeks (within a generation) or 2) after up to three successive applications of insecticides or miticides with the same mode of activity.
Real-Life 8-Week Rotation Programs

• Aphids:
  – Endeavor > Marathon > Ultra-Pure Oil > Orthene
• Thrips:
  – Conserve > Pylon > Avid > Overture
• Twospotted Spider Mite:
  – Floramite > Pylon > Akari > TetraSan
• Whiteflies:
  – Safari > Distance > Judo > Talus
• Mealybugs:
  – TriStar > Orthene > M-Pede > Enstar
• Fungus Gnats:
  – Distance > Citation > Pylon > DuraGuard
Resistance is most likely to occur when a pesticide with a site-specific mode of action is continually used compared to a pesticide with a broad mode of activity. In general, this is true...however...
Ways To Avoid Pesticide Resistance

• Scout crops regularly to appropriately time applications of pesticides so as to target the most susceptible life stages (e.g. larvae, nymphs, and adults) of insect and/or mite pests.

• Implement proper cultural (water and fertility) and sanitation (weed removal) practices.

• Screen greenhouse openings to prevent insect pests from migrating into greenhouses.
• Use biological control agents or natural enemies.

• Use pesticides with broad modes of activity such as: insect growth regulators, insecticidal soaps, horticultural oils, selective feeding blockers, and beneficial fungi and bacteria.

• Reduce the frequency of applying insecticides and/or miticides to mitigate/delay resistance developing in arthropod pest populations.
Every Time You Apply A Pesticide You Are Placing “Selection Pressure” On The Insect And/Or Mite Pest Population. Therefore, Reducing The Use Of Pesticides Will Lessen The Potential For Insect And/Or Mite Pest Populations To Develop Resistance 😊
Will Integrating Biological Control Agents With Pesticides Alleviate Pesticide Resistance?

It Depends!

Thank You For Your Attention!

I Hope You All Learned Something!
Questions or What’s Bugging You?