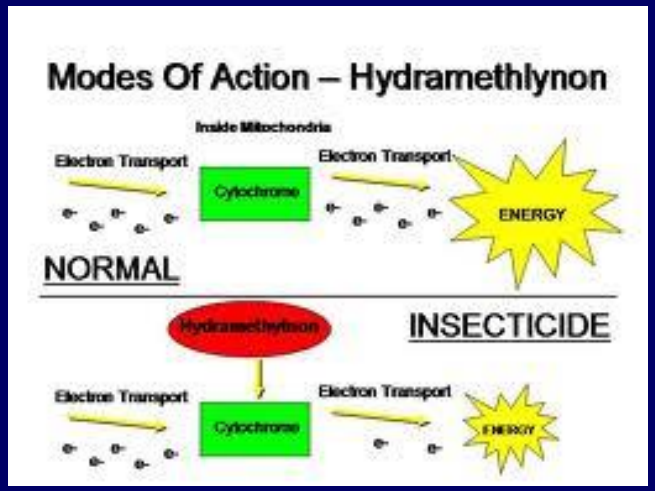
Great Plains Growers Conference And Trade Show

January 12, 2017
St. Joseph, MO



Resistance Management In Greenhouse Food Crops

Raymond A. Cloyd

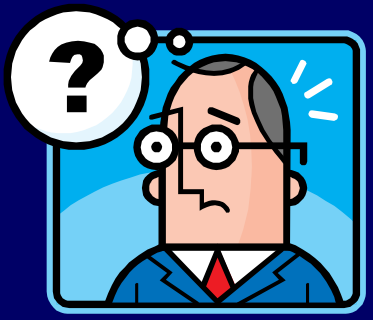
Professor and Extension Specialist in Horticultural Entomology/Plant Protection

Kansas State University, Manhattan, KS

Phone: 785-532-4750 **Email: rcloyd@ksu.edu**

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).

Pesticide Resistance 1980's

Pest Species	Resistant to Insecticides??
Aphis gossypii	30
Myzus persicae	68
Bemisia spp.	33
Tetranychus urticae	72
Frankliniella occidentalis	13

* 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.**

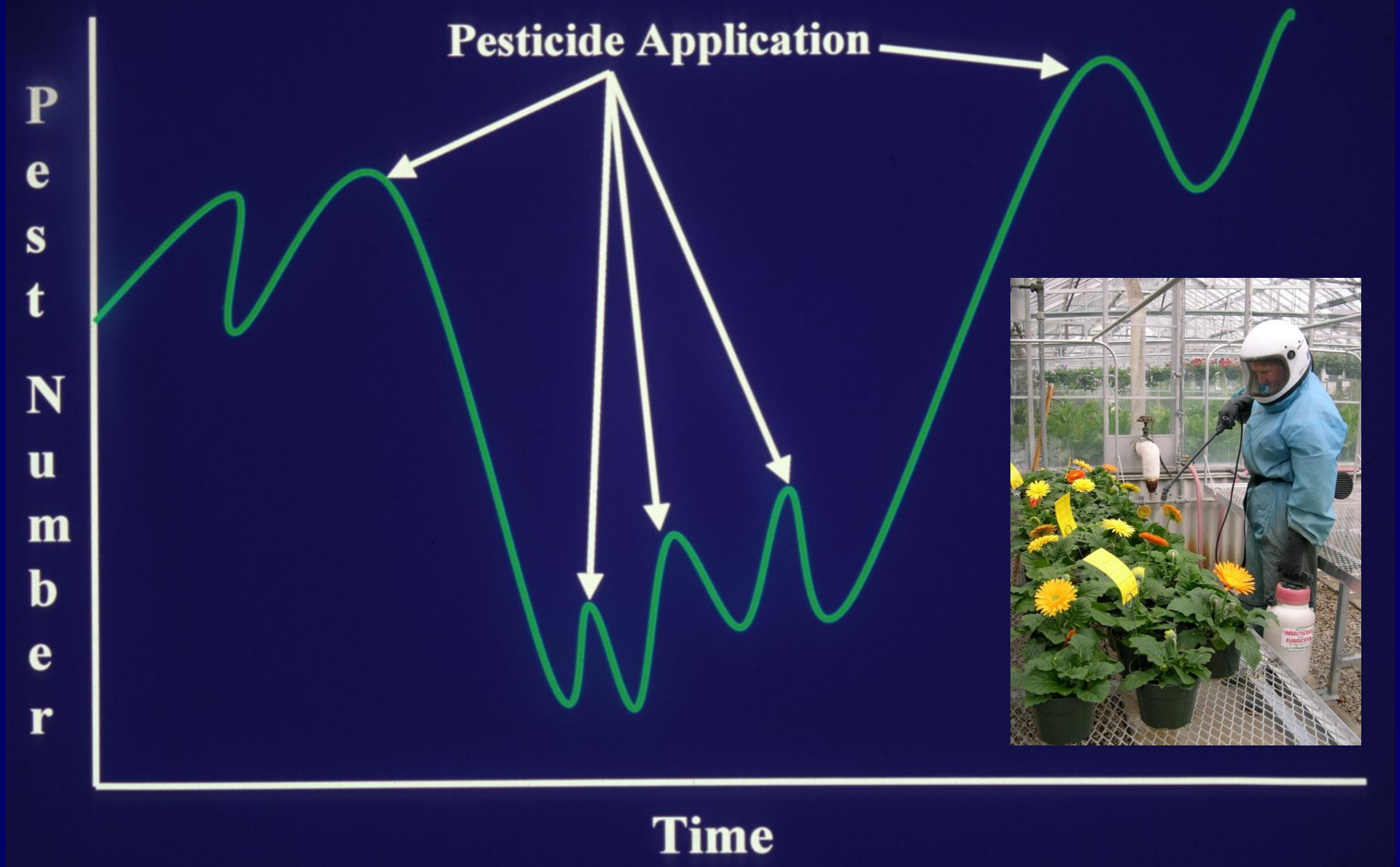
Resistance

- 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.

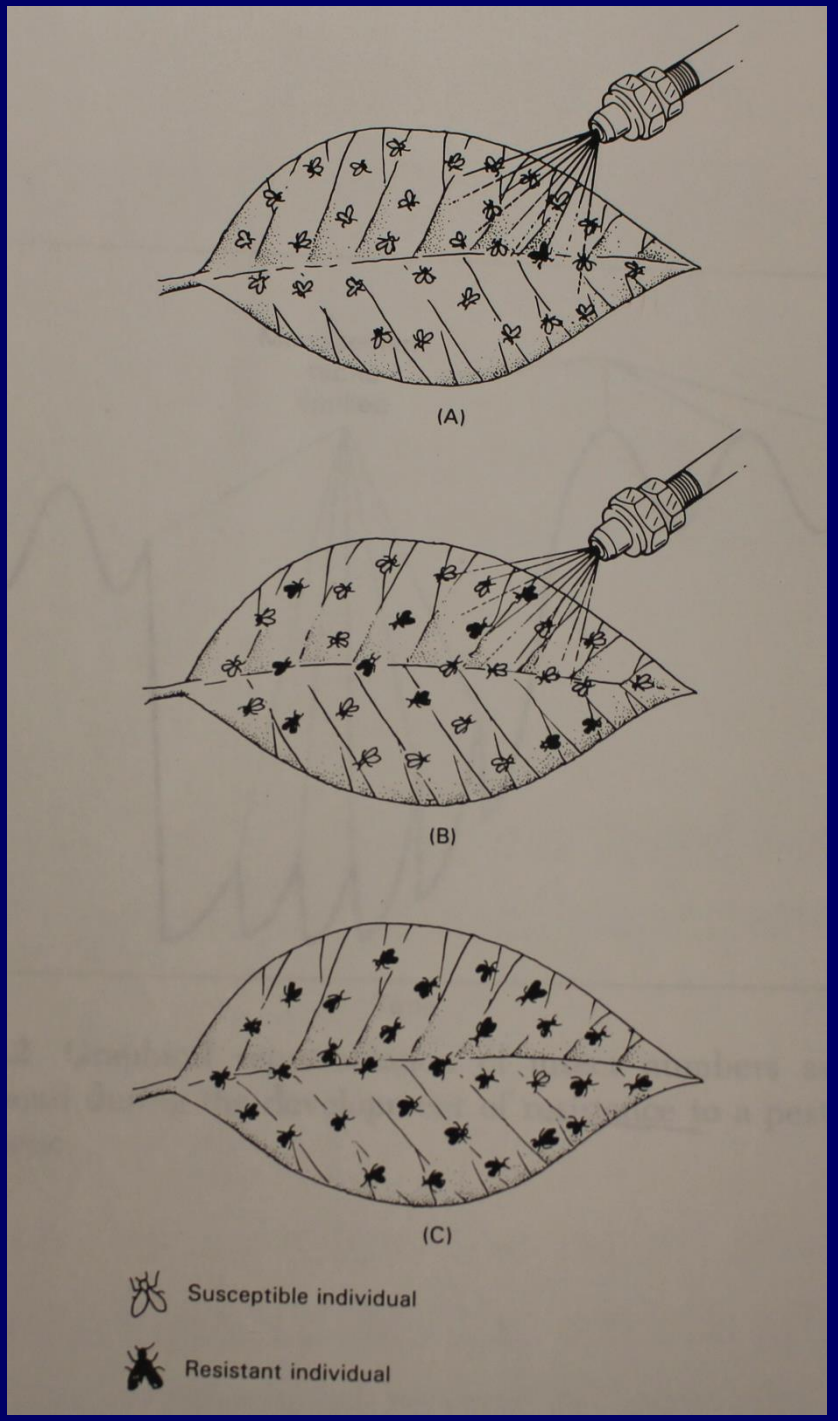
- No insecticide or miticide is "resistant proof."


OK…There Are Exceptions!

“Selection Pressure” Placed on Arthropod Pest Population: Influences Speed Of Resistance


Pesticide Application
Pest Number
Time

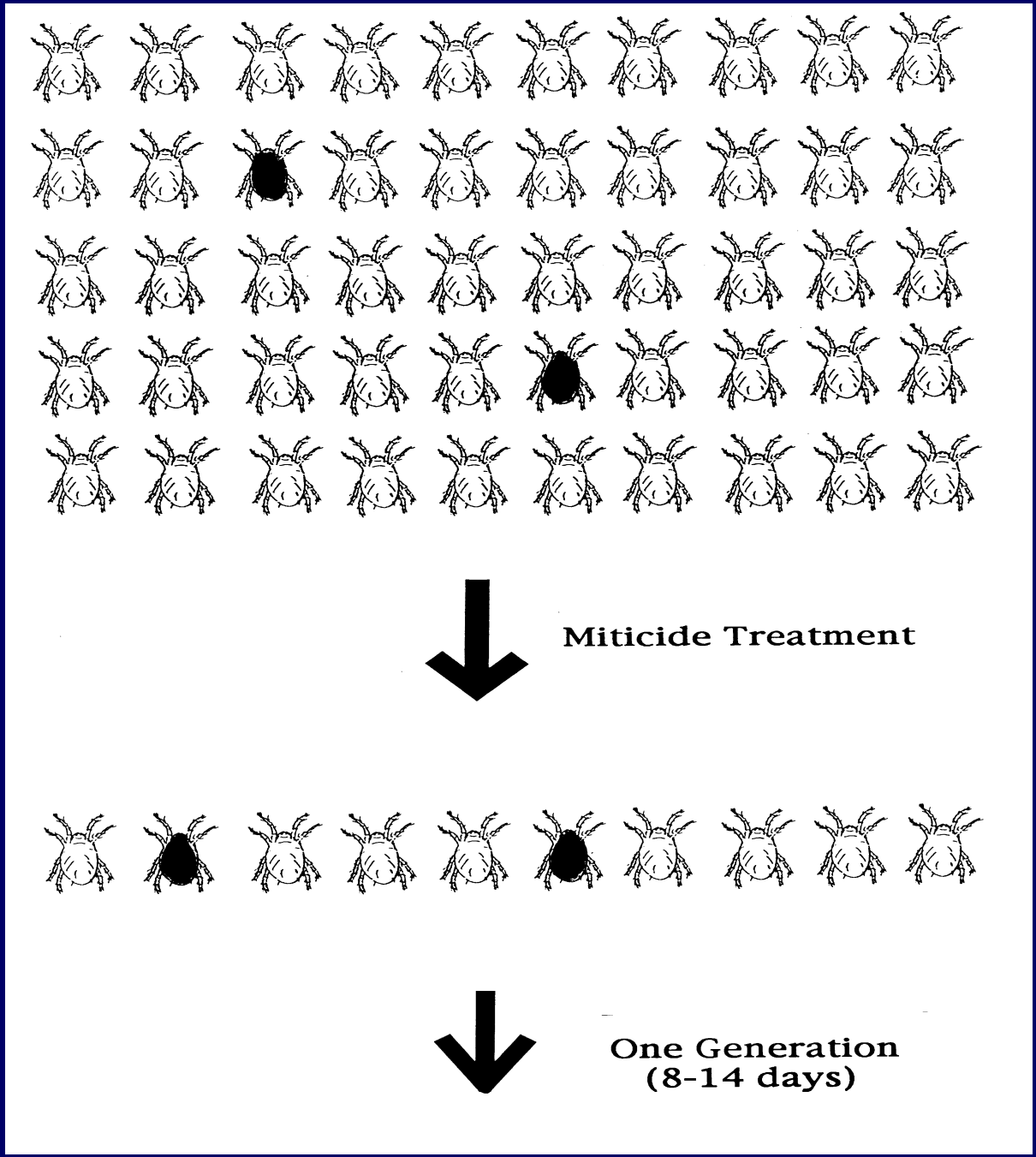
How Resistance Develops In An Insect And Mite Population When Exposed To Pesticides (Insecticides And Miticides)



Frequency of Resistant Individuals=4%

Resistance Development

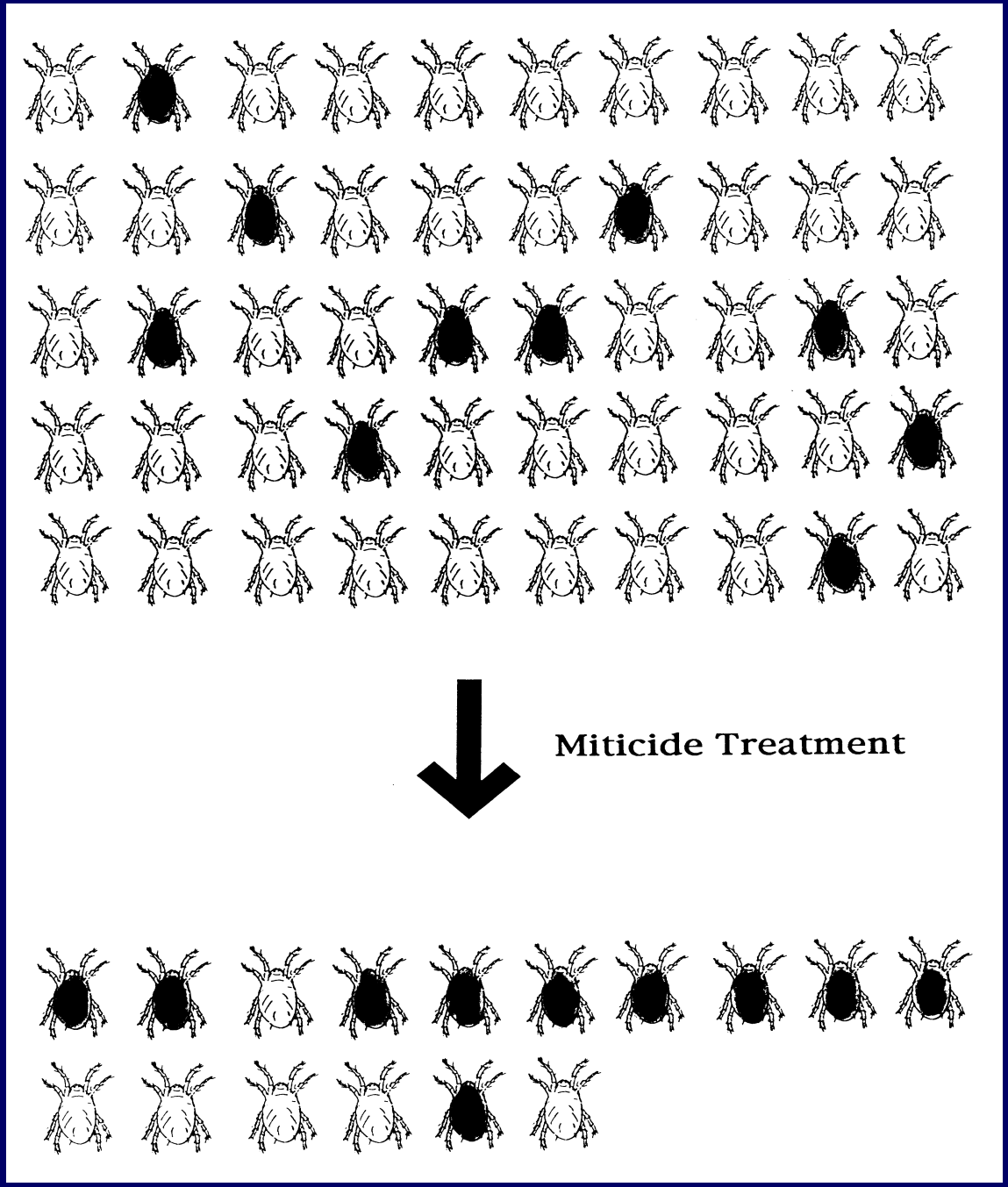
Frequency of Resistant Individuals=20%



Frequency of Resistant Individuals=20%

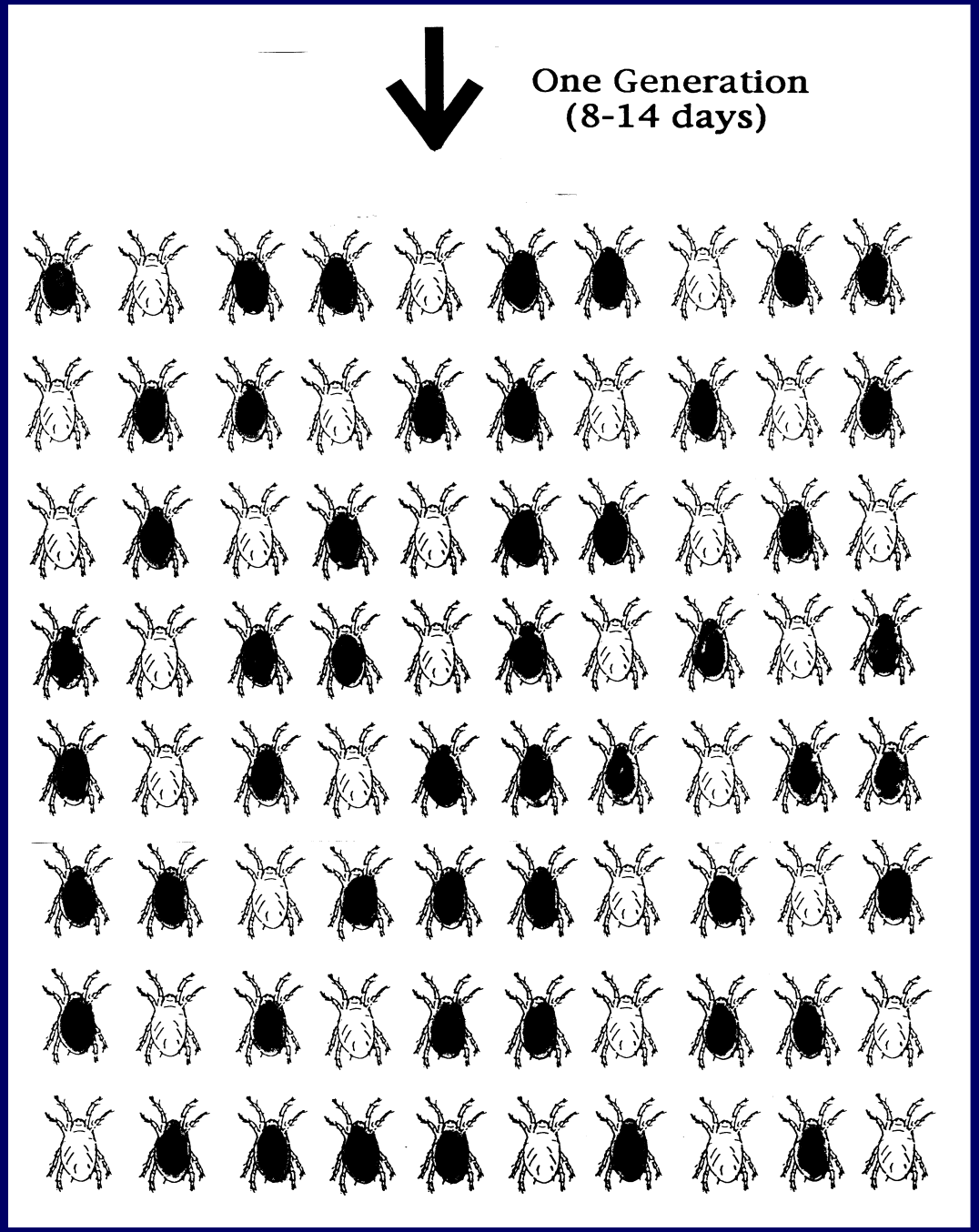
Resistance Development

Frequency of Resistant Individuals=63%



Resistance Development

Frequency of Resistant Individuals=63%



Resistance

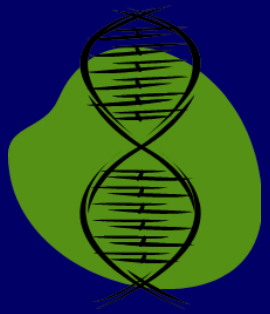
- "Selection pressure" for resistance increases as application frequency increases. Especially when insecticides and miticides with the same mode of action are applied in succession.

- 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

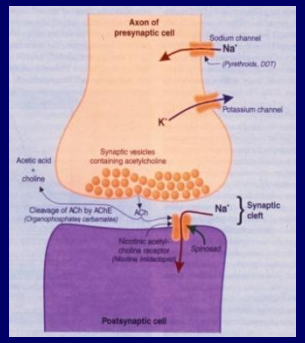
- Behavioral Resistance

- 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.**

- **<u>Haplo-diploid (arrhenotoky)</u> 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

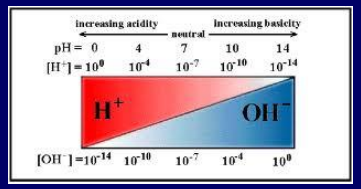
4. Targeted Life Stage

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

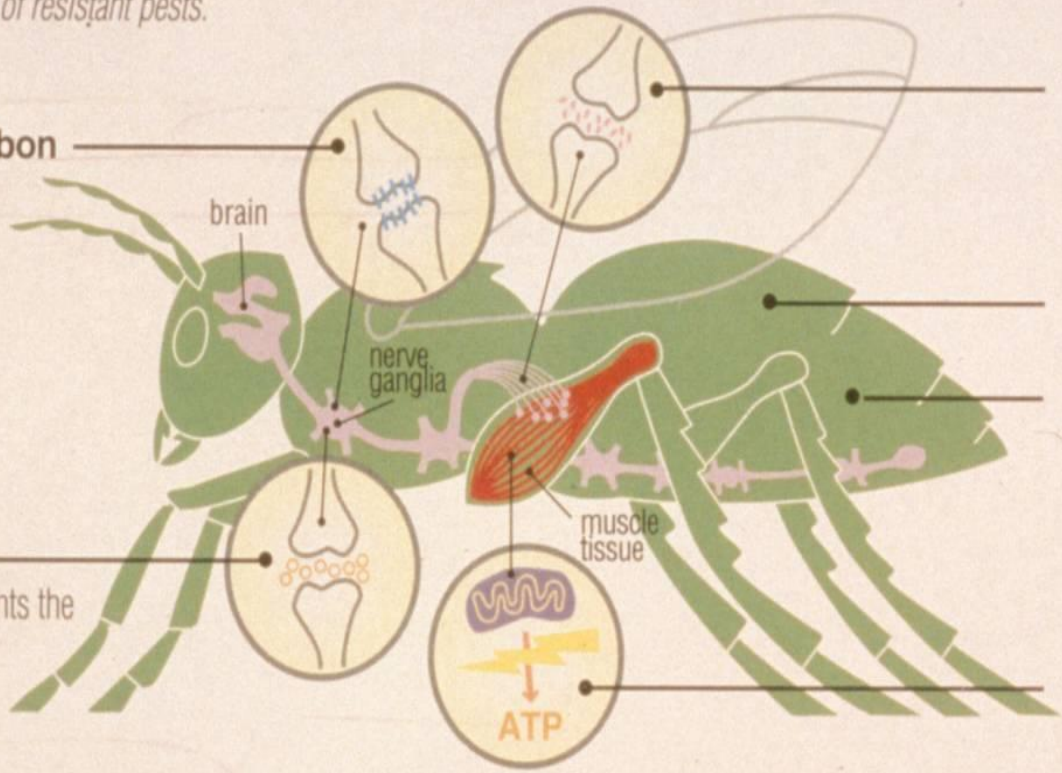
- **Narrow-Spectrum (site-specific) Modes of Action:**
  - **Pesticides that are active on specific target sites such as the central nervous system or enzymes associated with metabolism.**

- **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

Insecticide 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.

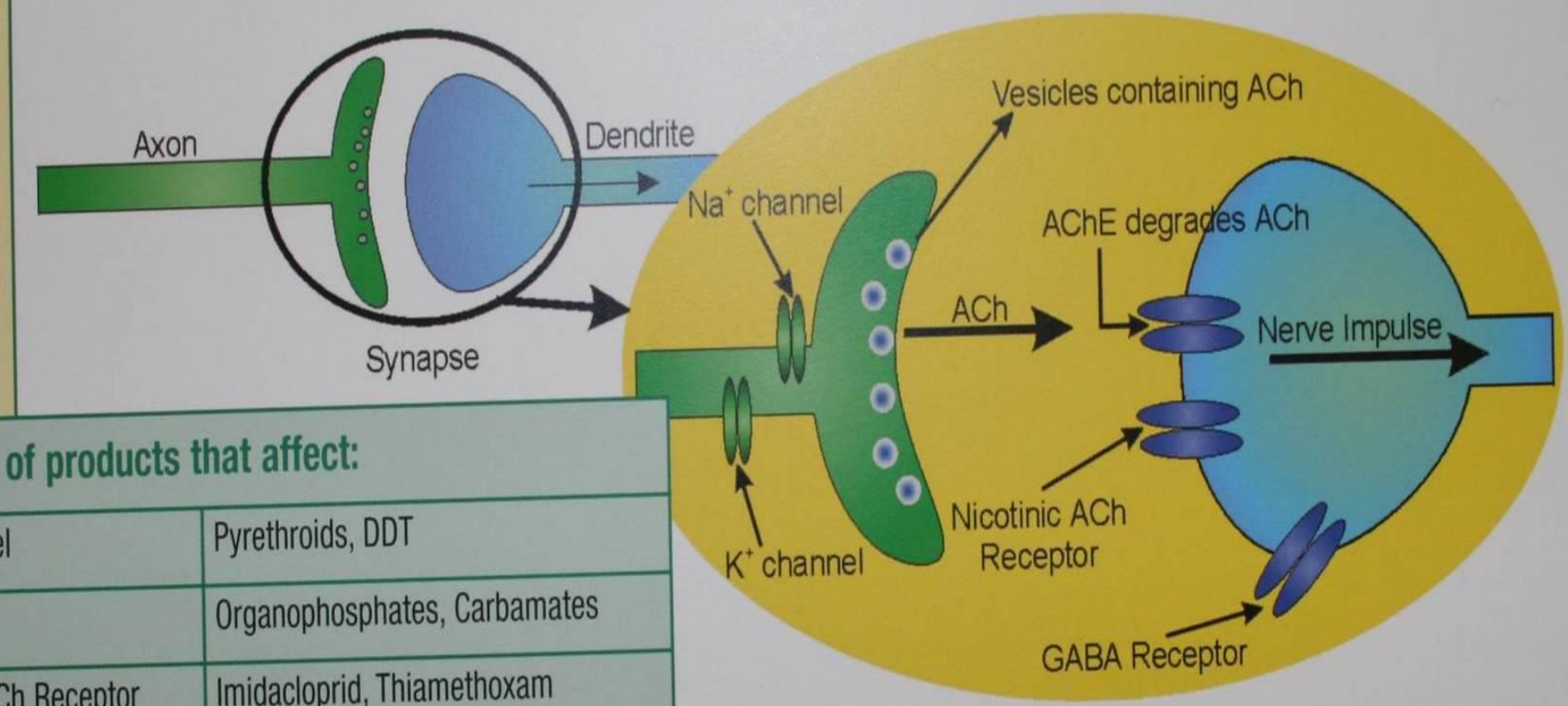
Abamectin
Affects GABA-dependent chloride ion channel, inhibiting nerve transmission.

Growth Regulators
(Chitin synthesis inhibitors and juvenoids)

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

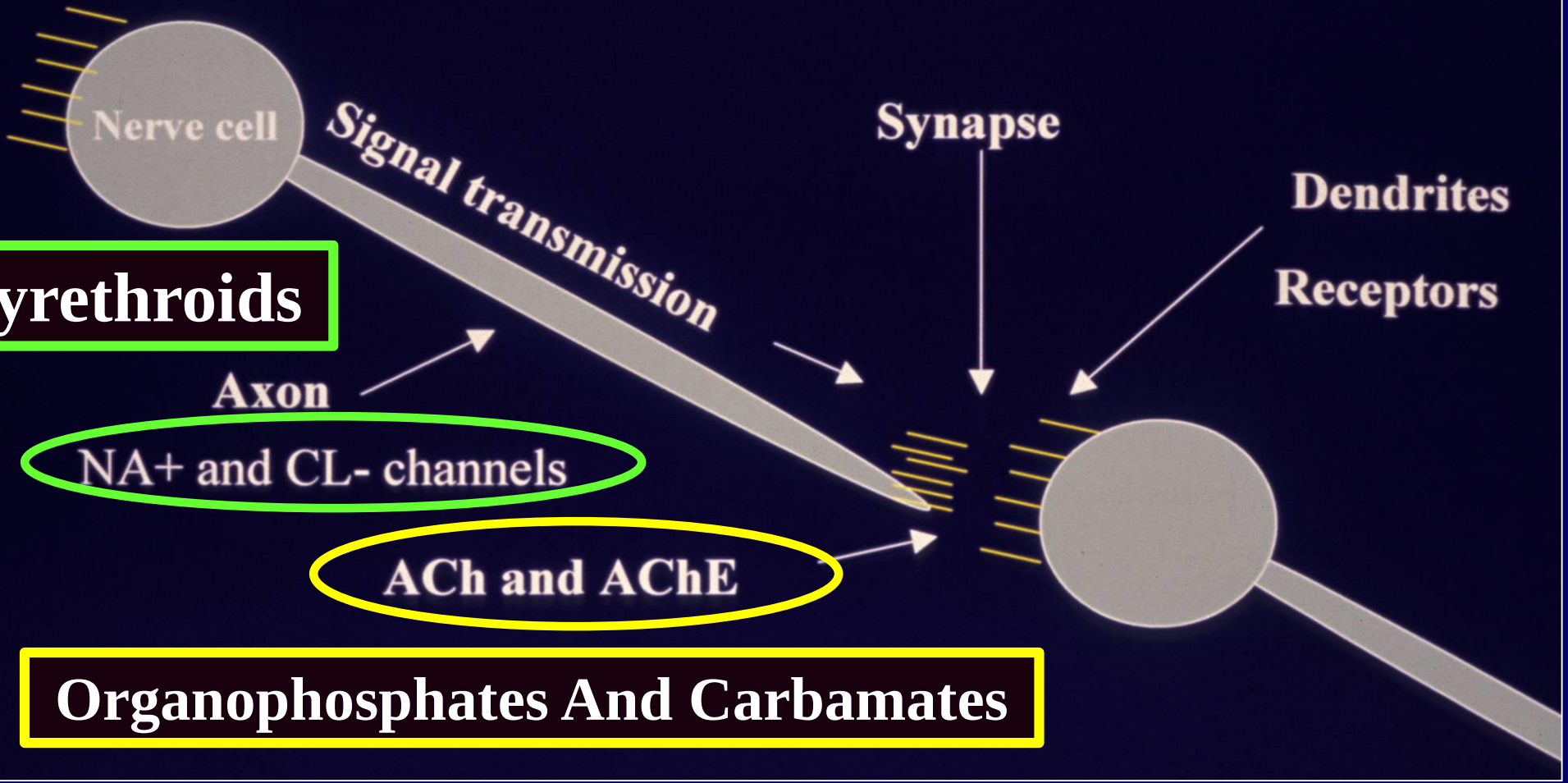
Pyridazinone (SANMITE)
Mitochondrial electron transport inhibitor (METI) blocks respiration within the insect cell.

Target Site Of Insecticides And Miticides



Example of products that affect:	
Na* channel	Pyrethroids, DDT
AChE	Organophosphates, Carbamates
Nicotinic ACh Receptor	Imidacloprid, Thiamethoxam
GABA Receptor	Avermectin, Fipronil, Cyclodienes
Unique Target Site	**Spinetoram**, Spinosad

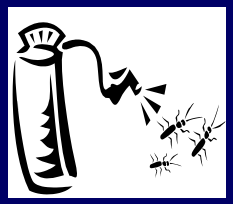
NERVOUS SYSTEM



Pyrethroids

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.

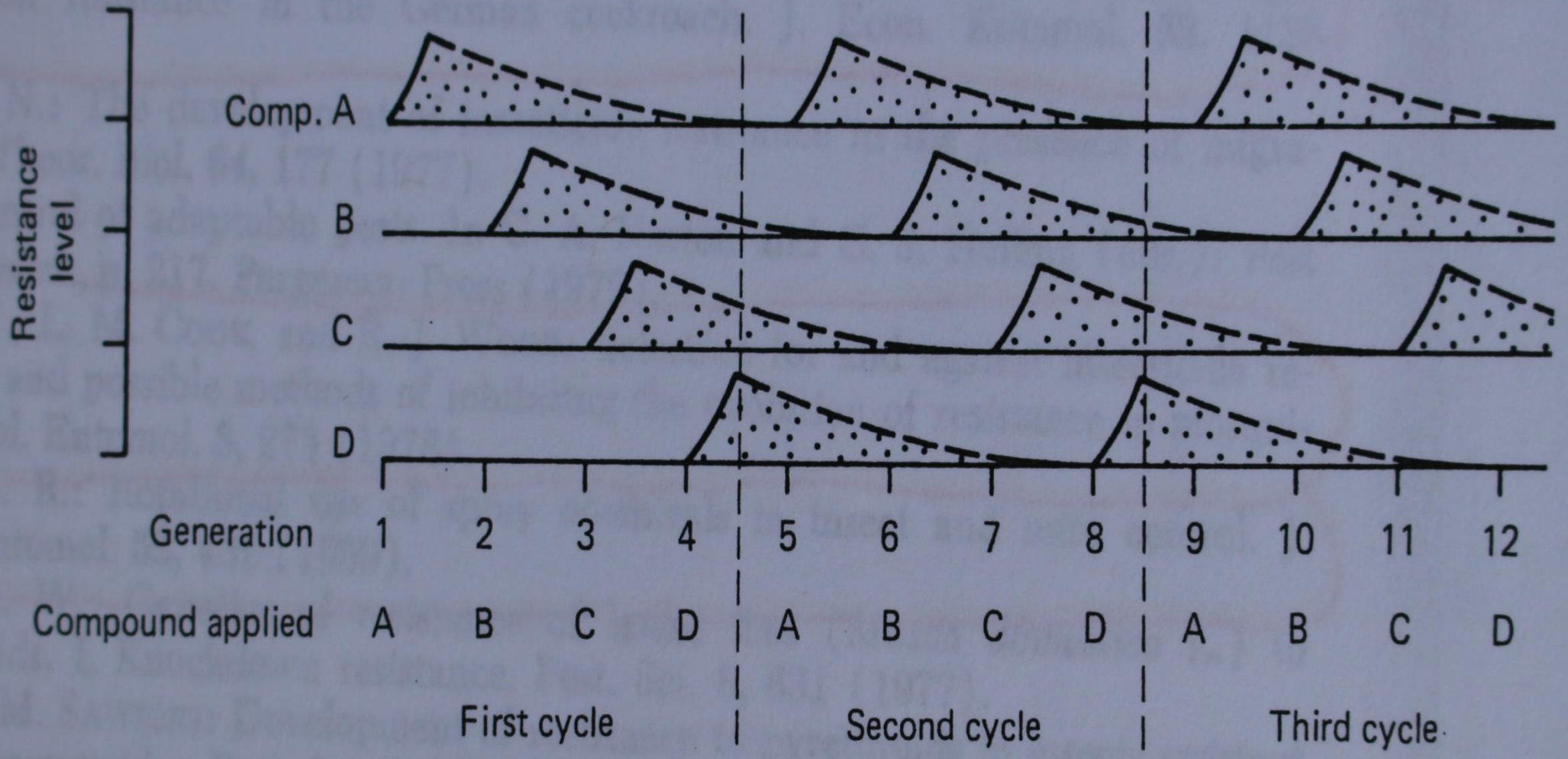


Fig. 6. Diagrammatic representation of expected oscillations in susceptibility of a population that is exposed to 4 unrelated chemicals (A–D) used in rotation against succeeding generations (1–12).

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.**

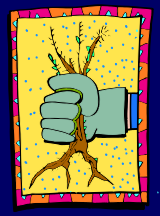
Real-Life 8-Week Rotation Programs

- **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.



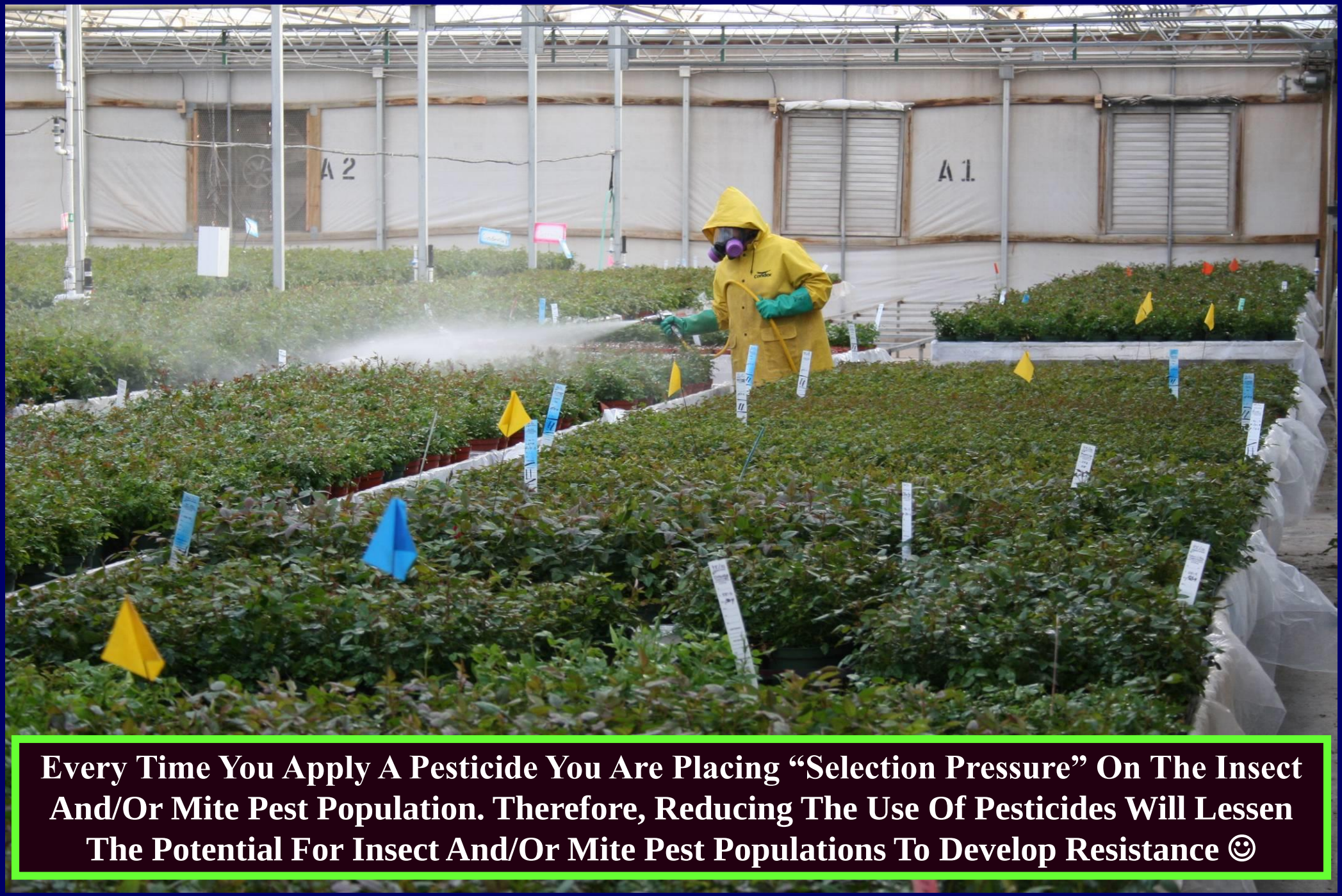
- Implement proper cultural (water and fertility) and sanitation (weed removal) practices.

- 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!

Extension Publication

- Cloyd, R. A., and R. S. Cowles. January 2010. Resistance Management: Resistance, Mode of Action, and Pesticide Rotation. 8 pages.

http://www.bookstore.ksre.ksu.edu/pubs/MF2905.pdf

Resistance Management

Resistance, Mode of Action, and Pesticide Rotation

K-State Research and Extension

Resistance management is a strategy designed to preserve or sustain pesticide effectiveness. Although the concept of resistance usually is associated with arthropod (insect and mite) pests, there are a number of plant pathogens that have demonstrated resistance (e.g., *Botrytis cinerea* or gray mold) to certain fungicide classes. In addition, many weed species are resistant to pre- and postemergence herbicides. This fact sheet focuses on resistance management of plant-feeding arthropods. Avoiding resistance in disease and weed management is equally important.

Arthropod pests in greenhouses and nurseries are principally managed with pesticides (insecticides and miticides). These pests possess the inherent ability to adapt to various environmental and human disturbance factors such as pesticide applications. Continual reliance on pesticides leads to resistance, which is the genetic ability of some individuals in a population to survive exposure. In other words, the pesticide no longer kills a sufficient number of individuals to be considered effective.

Resistance is an international concern with expanding global trade. Plant material can spread arthropod pests as well as resistant genes associated with those pests. Resistance is an inherited trait. Evolution of resistance in a population depends on existing genetic variability that permits some individuals to survive exposure to a pesticide. Surviving individuals transfer traits to the next generation, enriching the gene pool with resistant genes. The "selection pressure," or proportion of the population killed by a pesticide, is the main factor that influences resistance. Genetic variation related to pesticide susceptibility also is important.

Every time an arthropod pest population is exposed to a pesticide, there is potential selection for resistance, which increases the frequency or proportion of resistant genes within that population. Traits providing adaptive advantage include rare versions of genes that diminish sensitivity to a particular pesticide, or altered gene expression that

generation time and high female fecundity, which is the ability to produce large numbers of offspring in a single generation. In addition, some arthropod pests, including the twospotted spider mite (*Tetranychus urticae*) and western flower thrips (*Frankliniella occidentalis*), have haplo-diploid breeding systems that accelerate the rate of resistance development. Genes associated with resistance are fully expressed in haploid (single set of chromosomes) males in haplo-diploid species. With entirely diploid (double set of chromosomes) species, resistance may be partially hidden as recessive or co-dominant traits.

Twospotted spider mite (above) and western flower thrips (below).

Genes for resistance typically occur at a low frequency in an arthropod pest population before a pesticide is applied. An individual does not become resistant, but frequent applications of a given pesticide over multiple generations remove susceptible individuals, leaving resistant individuals to reproduce. The result is a pest population that can no longer be controlled with a given pesticide.

Resistance also may develop as arthropod pests move

Resistance Management

Resistance, Mode of Action, and Pesticide Rotation

K-State Research and Extension

Resistance management is a strategy designed to preserve or sustain pesticide effectiveness. Although the concept of resistance usually is associated with arthropod (insect and mite) pests, there are a number of plant pathogens that have demonstrated resistance (e.g., *Botrytis cinerea* or gray mold) to certain fungicide classes. In addition, many weed species are resistant to pre- and postemergence herbicides. This fact sheet focuses on resistance management of plant-feeding arthropods. Avoiding resistance in disease and weed management is equally important.

Arthropod pests in greenhouses and nurseries are principally managed with pesticides (insecticides and miticides). These pests possess the inherent ability to adapt to various environmental and human disturbance factors such as pesticide applications. Continual reliance on pesticides leads to resistance, which is the genetic ability of some individuals in a population to survive exposure. In other words, the pesticide no longer kills a sufficient number of individuals to be considered effective.

Resistance is an international concern with expanding global trade. Plant material can spread arthropod pests as well as resistant genes associated with those pests. Resistance is an inherited trait. Evolution of resistance in a population depends on existing genetic variability that permits some individuals to survive exposure to a pesticide. Surviving individuals transfer traits to the next generation, enriching the gene pool with resistant genes. The "selection pressure," or proportion of the population killed by a pesticide, is the main factor that influences resistance. Genetic variation related to pesticide susceptibility also is important.

Every time an arthropod pest population is exposed to a pesticide, there is potential selection for resistance, which increases the frequency or proportion of resistant genes within that population. Traits providing adaptive advantage include rare versions of genes that diminish sensitivity to a particular pesticide, or altered gene expression that

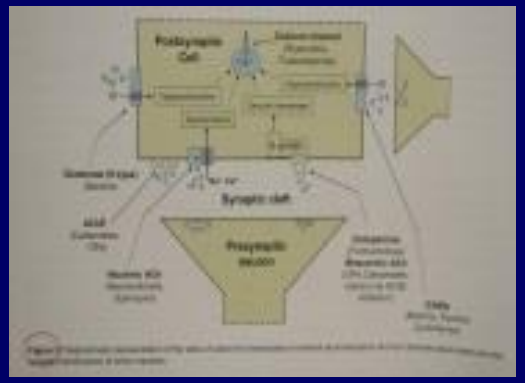
generation time and high female fecundity, which is the ability to produce large numbers of offspring in a single generation. In addition, some arthropod pests, including the twospotted spider mite (*Tetranychus urticae*) and western flower thrips (*Frankliniella occidentalis*), have haplo-diploid breeding systems that accelerate the rate of resistance development. Genes associated with resistance are fully expressed in haploid (single set of chromosomes) males in haplo-diploid species. With entirely diploid (double set of chromosomes) species, resistance may be partially hidden as recessive or co-dominant traits.

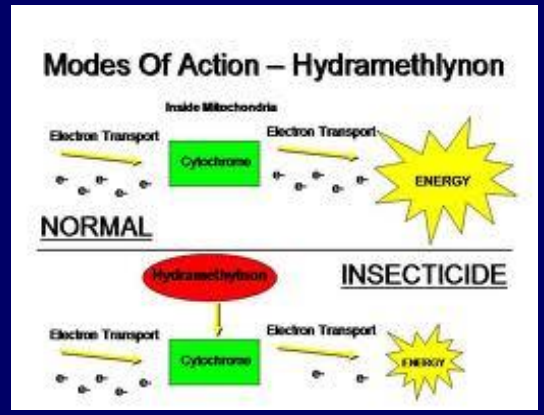
Twospotted spider mite (above) and western flower thrips (below).

Genes for resistance typically occur at a low frequency in an arthropod pest population before a pesticide is applied. An individual does not become resistant, but frequent applications of a given pesticide over multiple generations remove susceptible individuals, leaving resistant individuals to reproduce. The result is a pest population that can no longer be controlled with a given pesticide.

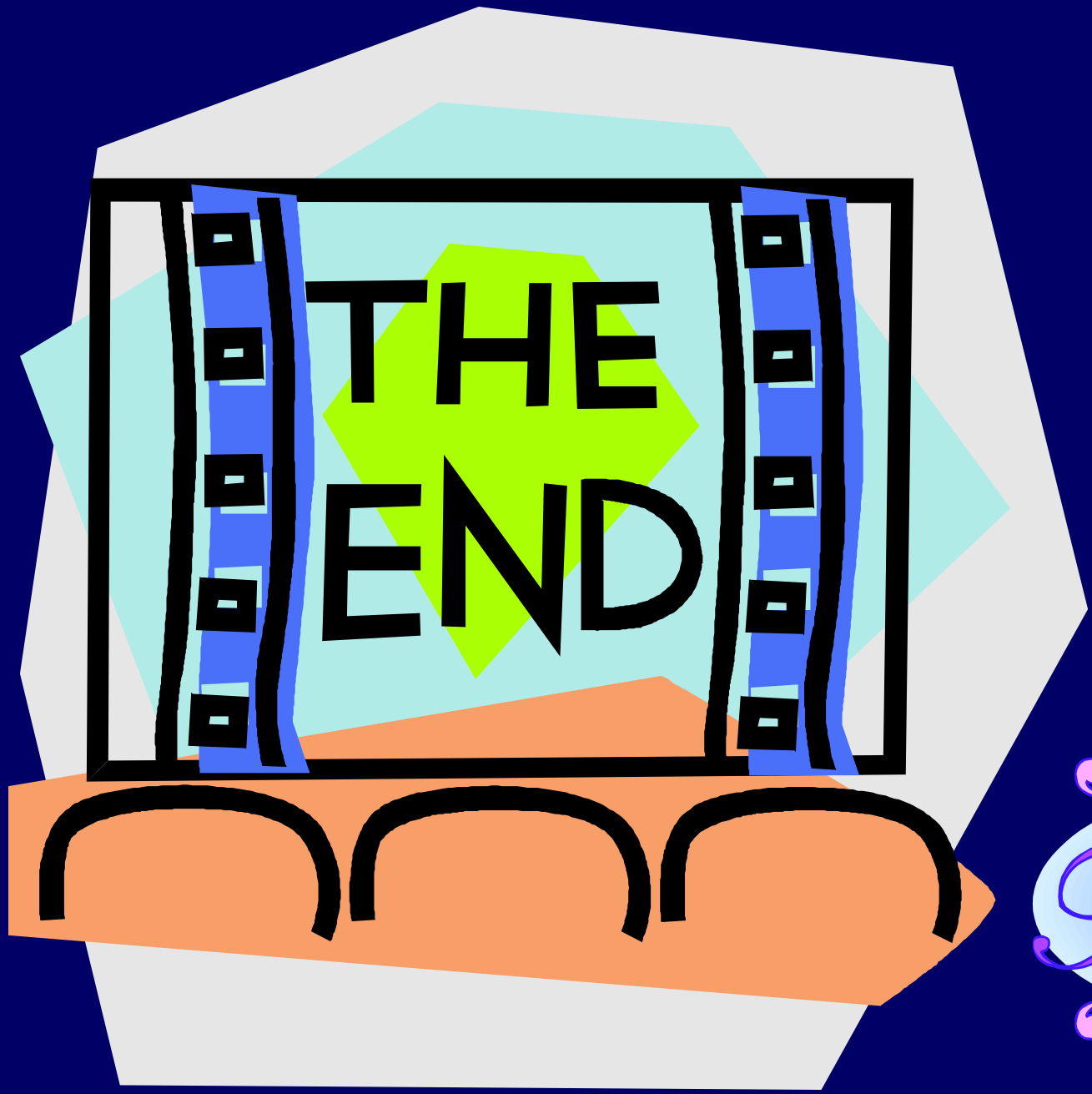
Resistance also may develop as arthropod pests move

Thank You For Your Attention!





I Hope You All Learned Something!



DONE!

The End

Questions or What's Bugging You?