Truth Behind Resistance Management

The facts you need to know about the growing problem of insect resistance and what you can do to prevent it.

By Ray Cloyd

Resistance management is a strategy often emphasized to preserve the effectiveness of currently available insecticides, miticides, fungicides and herbicides. Although the concept of resistance is usually associated with insects and mites, there are

Top: Western flower thrip. *Bottom:* Adult whitefly. (All photos courtesy of Ray Cloyd)

a number of plant pathogens including fungi that have been shown to be resistant to fungicides. For example, certain strains of *Botrytis cinerea* are known to be resistant to fungicides in the class dicarboximide [Chipco 26019 (Bayer)]. Besides insects/mites and diseases, many weed species are tolerant to pre- and post-emergent herbicides. In this article I will focus on resistance management as it relates to plant-feeding insects and mites, although avoiding resistance is just as important in disease and weed management.

Resistance management is oftentimes a common topic of discussion at grower meetings. Greenhouse managers should be cognizant of resistance and implement resistance management strategies, such as rotating insecticides/miticides with different modes of action, when dealing with insects or mites in greenhouse production facilities. The reason for this is that insects and mites can evolve in response to various environmental and human disturbance factors. For example, more than 500 species of insects and mites have developed resistance to insecticides/miticides over the past 40 years. This is an average of 13 insect or mite species per year.

Before we begin, it is important to understand the concept of resistance and how it affects the management of insect and mite pests (for those of you who remember your genetics, get ready). Resistance is the genetic ability of some individuals in a pest population to survive an insecticide/miticide application or a genetic modification that results in diminished sensitivity of an insect or mite population to a particular insecticide/miticide. This is due to the intensive mortality placed on insect/mite populations from frequent (too many) applications of insecticides/miticides resulting in the amplification of already-existing genetic traits and a higher number of resistant individuals. The selection of individuals in an insect or mite population to overcome this "burden" results in insect or mite populations able to tolerate applications of particular insecticides/miticides. Simply put, resistance is the genetic ability of some individuals (insects and mites) in a population to survive an insecticide/miticide application. Resistance is an inherited trait. The gene(s) for resistance may already be present in the insect or mite population. Insecticide/miticide use favors the survival of these resistant individuals. In addition, surviving insects or mites can pass resistant genes on to their offspring.

RESISTANCE MECHANISMS

Insects and mites may develop

resistance to insecticides/miticides via a number of mechanisms.

Metabolic resistance. Breakdown of the active ingredient by an insect or mite. When the insecticide or miticide enters the body, enzymes that detoxify or convert the material into a non-toxic form attack it. It is then excreted out with other waste products.

Physical resistance. A change in the cuticle (skin) that reduces or decreases penetration of the insecticide or miticide. For example, young mealybug crawlers don't have a protective covering, which is why they are more susceptible to insecticide applications, whereas mature mealybugs possess a white, waxy covering, which inhibits insecticide penetration into the body.

Physiological resistance. An insect or mite modifies the target site of the insecticide or miticide, which decreases sensitivity to the active ingredient at the physical point of attack because the target site has been altered.

Behavioral resistance. Insects or mites avoid contact with an insecticide or miticide by hiding in locations such as terminal growing points that are difficult for an insecticide/miticide to penetrate.

Natural resistance. General type of resistance in which the insect or mite, or life stage is not susceptible to an insecticide/miticide. For example, in general, the eggs and pupae stages of most insects and mites are not negatively affected by contact or systemic insecticides/miticides.

RATE OF RESISTANCE

There are a number of factors that may influence the rate of resistance development within an insect/mite population.

General Operational Procedures. General operational procedures that may influence the rate of resistance include making insecticide/miticide applications on a frequent basis regardless of pest population dynamics. This increases the selection pressure on insect or mite populations, thus leading to the development of resistant individuals. Always using the highest label rate and/or using the same insecticide/miticide or using insecticides/miticides with similar modes of activity for an extended period of time also increases the selection pressure placed on pest populations.

Biological Characteristics. Biological characteristics of insects and mites that may increase the rate of resistance include rapid development time (short generation time and rapid transfer of resistant genes), high reproductive rate (large number of offspring produced per generation), high mobility and wide host range. Remember that resistant genes in insect or mite populations can be passed on to future generations or progeny. All of these biological characteristics may result in increased exposure to insecticide or miticide applications.

Greenhouse Conditions. Greenhouse conditions that can lead to an increase in resistant individuals include environmental parameters (temperature and relative humidity), that are conducive for insect and mite development. The greenhouse generally encloses insect and mite pests and restricts the movement of susceptible individuals into the population. Therefore, resistant individuals are dominant and remain in the greenhouse and breed, whereas susceptible individuals from areas not treated with insecticides/miticides are unable to enter and breed with resistant insects or mites. Furthermore, intensive year-round production in greenhouses provides a continuous food supply for insects and mites, and this often results in frequent exposure to insecticide/miticide applications.

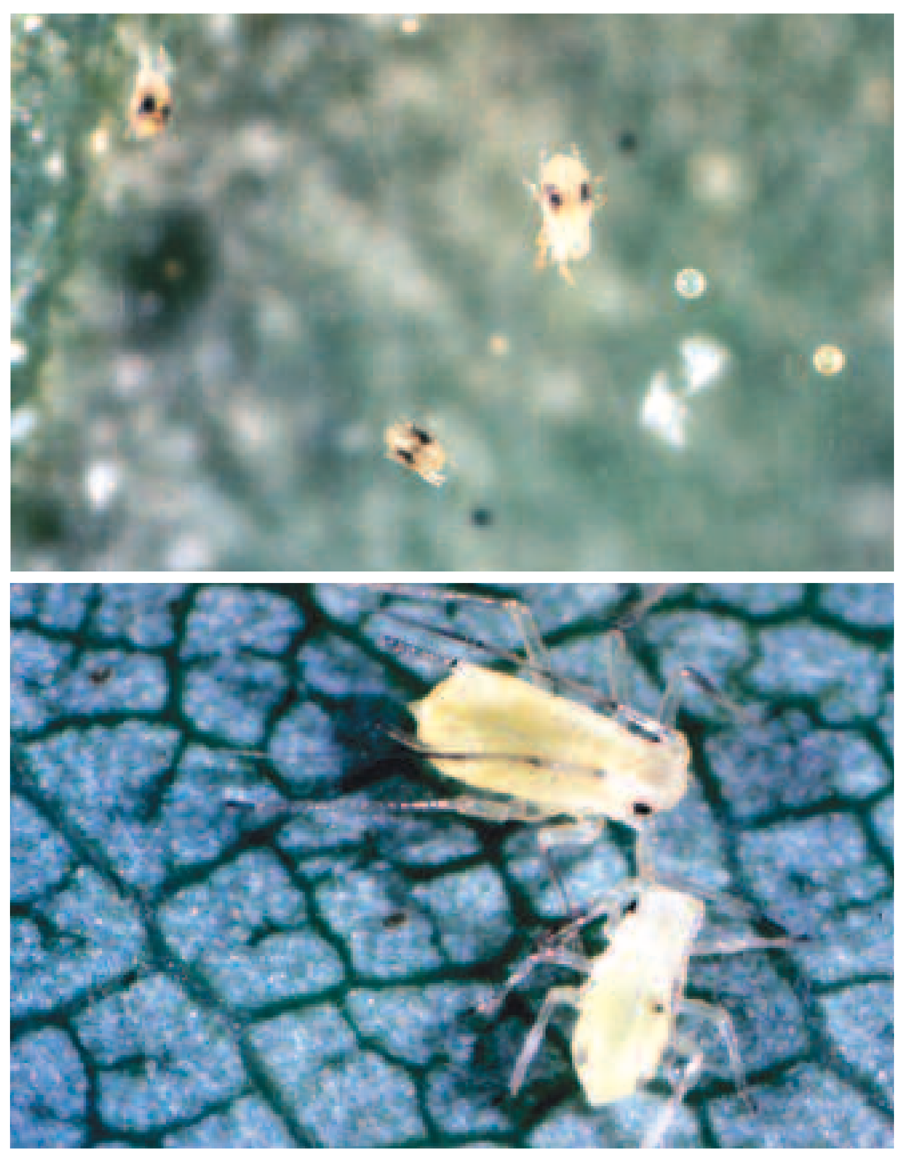
Resistance may also occur or develop due to the movement of insects/mites within and into greenhouses. There are three ways that immigration of insects/mites may result in resistance. First, insects or mites that migrate from other crops within the greenhouse or between greenhouses increase the likelihood that these insect/mite populations will be exposed to additional insecticide/miticide applications. Second, receiving plants with insects or mites that have been previously exposed to insecticide/miticide treatments may enhance resistance development, as a large percentage of these insects/mites may already possess resistant genes.

Finally, insects or mites that enter the greenhouse from field or vegetable crops may have been exposed to agricultural insecticides/miticides that are similar to those used in greenhouses.

The rate of resistance development may depend on the season. The number of insecticide/miticide applications, based on the population dynamics of the insect or mite population, may vary throughout the year, especially during fall/winter and spring/summer. The likelihood of resistance developing may increase during spring/summer, as this is when insect and mite populations are typically higher thus requiring more frequent insecticide/miticide applications.

IMPLEMENTING MANAGEMENT

Develop a holistic pest management program. The program should include cultural, physical, chemical and biological controls that minimize pest problems. This may reduce the number of insecticide/miticide applications needed and reduce the amount of selection pressure placed on insect or mite populations. Also, scouting crops and monitoring for pests on a regular basis throughout the growing season will determine the population dynamics of insect/mite populations and help you time ➧



Top: *Twospotted spider mites.* ***Bottom:*** *Aphids.*

insecticide/miticide applications accordingly or determine if an application is needed.

Minimize use of tank mixes. Greenhouse managers mix insecticides and miticides together in order to manage the myriad of insect and mite pests that may be present. However, tank mixing insecticides and miticides with different (and specific) modes of activity may lead to multiple resistance or resistance to two different insecticides/miticides. Insect or mite populations that have acquired resistance to two different insecticides/miticides with different modes of activity are very difficult to manage and will limit options. Use mixtures of insecticides/miticides with specific modes of activity only when absolutely necessary to obtain control. Tank mixing site-specific mode of action insecticides/miticides with non-specific mode of action insecticides/miticides may prevent the development of resistance.

Mealybugs are difficult to control once they have reached the adult stage and possess a waxy covering. This is an example of physical resistance.

Use non-specific modes of activity. Use insecticides/miticides with non-specific modes of activity such as insect growth regulators, insecticidal soaps, horticultural oils and beneficial fungi or bacteria. Conventional insecticides and miticides tend to have site-specific modes of activity — inhibiting one vital function or target site. As a result, it takes only a single-gene mutation to avoid sensitivity to an insecticide or miticide. Systemic insecticides such as the neonicotinoid-based products [Marathon (Olympic), Flagship (Syngenta), Tristar (Cleary) and Safari (Valent)] have site-specific modes of action, thus the possibility of resistance developing in insect populations is greater. Biorational insecticides and miticides have non-specific or broad modes of activity, interfering with a number of vital functions or target sites. As a result, these insecticides/miticides are less likely to promote or less susceptible to resistance development in insect and mite populations. Conventional insecticides/miticides should be rotated or mixed with insecticides/miticides with non-specific modes of activity in order to preserve their longevity.

Use minimum label rates. Constant use of the highest label rate of an insecticide or miticide may result in limited options when this rate fails to provide control. The lower label rate may be just as effective as the highest label rate. If the lower label rate fails, then you have the option of using the middle or higher label rate. Most importantly, this preserves the longevity of currently available insecticides/miticides.

Time applications to kill the most vulnerable life stage. This is the "weak link in the chain" concept, where insects or mites have a developmental stage or stages that are more susceptible to insecticides/miticides. Generally, the immature or young stages are more susceptible to conventional or biorational insecticides/miticides. Understanding this can lead to a reduction in the number of applications required and thus decrease the amount of selection pressure placed on an insect or mite population by appropriately timing insecticide/miticide applications — based on scouting information.

Use biological control. Some greenhouse growers are able to use natural enemies including parasitoids, predators, pathogens and beneficial nematodes for part of the year or on some crops to control major insect and mite pests. Anything that can be done to reduce the selection pressure or frequent insecticide/miticide applications will help with resistance management.

Rotate insecticides and miticides with different modes of activity. Reliance on one chemical class (organophosphate, carbamate or pyrethroid) to manage insects or mites will result in high selection pressure placed on populations, increasing the potential for resistance development. Rotate insecticides and miticides with different modes of activity — not chemical classes. Use an insecticide or miticide for at least the duration of one generation of an insect or mite population (in general, every 2-3 weeks) before switching to an insecticide/miticide with a completely different mode of activity. This last year, I developed a list, which describes the modes of action for the insecticides and miticides used in greenhouses; you can find this in the October 2004 issue of *GPN*.

Tank mixing insecticides or miticides, particularly those with similar modes of action, may lead to problems with resistance.

For more information on chemicals mentioned in this article, please direct your inquiries or questions to the following companies.

Bayer Crop Science
(800) 842-8020
www.bayercropscienceus.com

Olympic Horticultural Products
(800) 659-6745
www.olympichort.com

Syngenta Professional Products
(866) SYNGENTA
www.syngentaprofessionalproducts.com

Valent USA Corp.
(800) 898-2536
www.valent.com

Cleary Chemical Corp.
(800) 545-9525
www.clearychemical.com

INSECTICIDES/MITICIDES

Many new insecticides/miticides with different modes of activity are being registered for use on greenhouse crops. This will help with resistance management if these insecticides/miticides are used properly. A number of currently available insecticides and miticides have labels that are resistance management oriented, stating that only one or two applications can be made and then an alternative insecticide/miticide must be used. Below are examples of labels that contain information related to resistance management.

Marathon (Olympic). Some insects are known to develop resistance to insecticides after repeated use. As with any insecticide, the use of this product should conform to resistance management strategies established for the use area. For resistance management purposes, a foliar application of any chloronicotinyl insecticide following a Marathon 1% G greenhouse and nursery insecticide soil incorporation in the same crop is not recommended.

Distance (Valent). Repeated use of the same class of insecticides or insecticides with similar modes of action can lead to the buildup of resistant insect strains. Whiteflies are especially prone to becoming resistant to insecticides. Distance should be used in alternation with other IGR materials possessing dissimilar modes of action and/or with other chemical classes of insecticides.

Avid (Syngenta). Treatment may not be effective against pests if Avid tolerant strains develop. Therefore, when applying Avid to plants that are hosts of labeled pests with multiple generations per crop per year, resistance management strategies must be used. Such strategies may include, but are not limited to, rotating products with different modes of action, avoiding treatment of successive generations with the same product, using labeled rates at specified spray intervals, using non-chemical alternatives such as beneficial arthropods, rotating susceptible to non-susceptible plants and implementing various cultural practices.

In conclusion, there are many ways to totally avoid resistance. This can be accomplished by utilizing a number of primitive control devices that will stop resistance "in its tracks" such as — a brick, old shoe and the ever-faithful fly swatter. In the end (for the insects and mites that is), there is no transfer of genes (you have to have a sense of humor about this stuff).

Resistance management is an important concept to understand in order to develop effective insect and mite management strategies. Greenhouse managers who are knowledgeable about resistance and the conditions that promote its development will be more effective in initiating insecticide/miticide stewardship programs, thus preserving those already existing products. GPN

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