GROWERTALKS

Pest Management

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Pesticide Resistance Revisited

Dr. Raymond A. Cloyd

Resistance occurs when arthropod pests (insect or mite) aren't killed when continually exposed to pesticide (insecticide or miticide) rates that were previously effective in suppressing arthropod pest populations. Therefore, a higher rate of a pesticide must be applied and more frequent applications will be required to achieve the same level of suppression.

Resistance is an unintended consequence of applying pesticides, resulting in selective elimination of susceptible individuals from an arthropod pest population following application of or long-term exposure to a pesticide. The surviving resistant individuals or strains can interbreed, creating a population that's tolerant or resistant to subsequent applications of the same pesticide or different pesticides with similar modes of action.

Resistance development

The rate of resistance development in an arthropod pest population is contingent on the frequency of applying pesticides, which results in selection pressure being placed on an arthropod pest population. The amount of selection pressure, based on the rate used and the frequency of applying a pesticide, increases the propensity for resistance to develop in arthropod pest populations. In addition, arthropod pests may be predisposed to develop resistance to pesticides because they already possess enzymes that detoxify compounds related to plant chemical defenses (allelochemicals), such as alkaloids and terpenoids. These same enzymes are also responsible for detoxifying pesticides.

There are two primary resistant mechanisms: 1) Enhanced metabolic detoxification, which involves enzymes detoxifying or converting the active ingredient of a pesticide into a non-toxic form that's then excreted out of the body; and 2) alterations in the target site that decreases the affinity (binding ability) of the active ingredient to the target site of a given pesticide (lock-and-key scenario).

Arthropod pest generations and pesticide applications

The number of generations per year associated with an arthropod pest population can influence the rate of resistance. Arthropod pests that have multiple generations per year or cropping cycle can rapidly develop resistance because of the intensity of selection pressure based on the frequency of applying pesticides. The number of pesticide applications and treated generations enhances the rate at which resistance develops. However, arthropod pest generations exposed to fewer pesticide applications or less selection pressure results in a slower rate of resistance developing.

In addition to the number of generations per year or cropping cycle, female reproductive capacity can increase the rate of individuals multiplying, which enhances the potential for females to transmit resistance traits to their offspring. Furthermore, arthropod pests with shorter life cycles are more likely to develop resistance because they're exposed to more pesticide applications within a given time period.

Arthropod pests that feed on a wide range of plants grown in greenhouses are more likely to develop resistance because of exposure to multiple pesticide applications, which increases selection pressure and the frequency of resistant individuals in arthropod pest populations. The application rate can select for resistant individuals at the expense of susceptible individuals, which favors an increase in the frequency of resistant individuals in an arthropod pest population. Furthermore, the number of pesticide applications and proportion of the treated population (number of host plants treated and number of susceptible individuals exposed) can influence the rate of resistance.

Factors that can affect resistance

Pesticides with minimal residual activity (persistence) may be applied more frequently by growers, resulting in rapid selection for resistant individuals in an arthropod pest population. Pesticides with extended residual activity (persistence) may allow for fewer applications. However, arthropod pests and subsequent generations will be exposed to continuous selection pressure, leading to the selection of resistant individuals in the arthropod pest population.

Pesticides with multiple-site modes of activity are less susceptible to resistance developing than specific-site modes of activity due to the multitude of target sites, which reduces the risk of resistance. Two factors associated with the biological characteristics of arthropod pests that affect the risk of resistance are: 1) Reproduction (number of generations per year); and 2) dispersal capability or mobility (ability to move among a crop). For example, insect pests that are mobile as adults (e.g., thrips, whiteflies and leafminers) may be more exposed to pesticide applications than insect or mite pests that are stationary (mealybugs, scales and spider mites).

Cross-resistance

Cross-resistance occurs when a single resistance mechanism (metabolic detoxification or alterations of the target site) confers resistance to pesticides in the same chemical class and/or pesticides having similar modes of action that work on the same target site. For example, spinosad and the neonicotinoids (imidacloprid, dinotefuran and thiamethoxam) have similar modes of action working on the nicotinic acetylcholine receptors, which may lead to cross-resistance. However, there are cases where cross-resistance occurs even when pesticides have dissimilar modes of action or work differently on target sites. In addition, cross-resistance to one pesticide frequently confers some level of resistance to other related pesticides that arthropod pest populations haven't been previously exposed to.

Twospotted spider mite and resistance

The twospotted spider mite (TSSM), *Tetranychus urticae*, feeds on over 1,100 plants from over 140 different plant families. Therefore, TSSM populations may be exposed to a broad spectrum of plant chemical defenses. However, the TSSM can overcome many plant chemical defenses and has demonstrated a propensity to develop resistance to pesticides, regardless of chemical class. In addition, resistance can occur within a few years after the introduction of a new miticide.

Selection for resistance in TSSM populations is exacerbated because of a high female reproductive capacity and a short life cycle. In addition, the haploid-diploid sex determination system, where unmated females produce haploid males, increases the potential for resistance development. In general, the resistance mechanisms associated with the TSSM include target site alterations and metabolic detoxification. It's important to understand that populations or strains of the twospotted spider mite resistant to currently available miticides used in greenhouse production systems may also exhibit resistance to miticides with new modes of action that haven't been used previously.

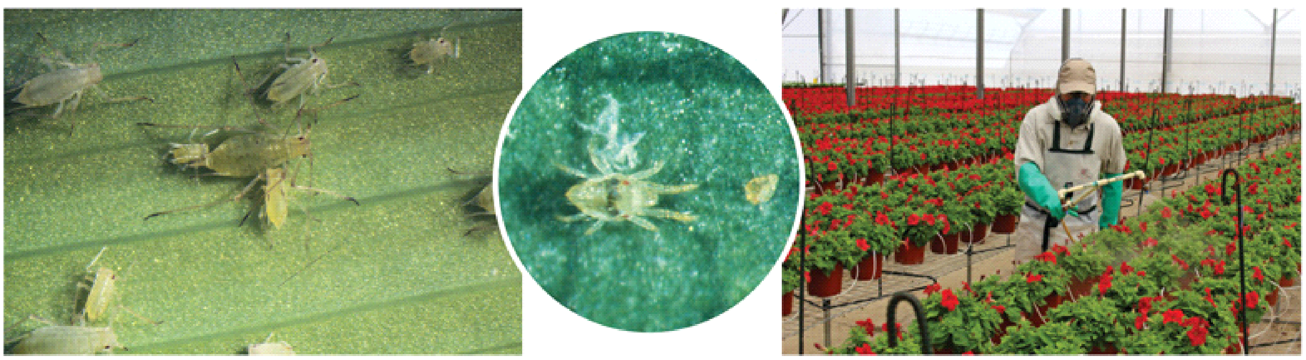
How can growers delay pesticide resistance?

Greenhouse producers can delay resistance by reducing the frequency of applying pesticides, rotating pesticides with different modes of action, releasing biological control agents—such as parasitoids and predators—and screening greenhouse openings. A reservoir of susceptible individuals is important in reducing the rate of resistance development. For example, the immigration or movement of susceptible individuals into treated areas can reduce the rate of resistance developing by increasing the frequency of susceptible individuals. However, leaving crops or areas of the greenhouse untreated with populations of arthropod pests may not be practical.

Conclusion

Greenhouse producers must understand the principles of resistance as presented in this article to preserve the efficacy and longevity of currently available pesticides (insecticides and miticides) so they can continue to have options in managing arthropod pest populations in greenhouse production systems. **GT**

Dr. Raymond A. Cloyd is a Professor and Extension Specialist in Horticultural Entomology/Plant Protection at Kansas State University. He can be reached at (785) 532-4750 or rcloyd@ksu.edu.



Left: Insects, such as aphids, that have multiple generations per year can rapidly develop resistance to pesticides. Center: Twospotted spider mite, Tetranychus urticae, has the innate propensity to develop resistance to pesticides. Right: Selection pressure associated with frequent pesticide applications fosters resistance development in arthropod pest populations.