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By Raymond Cloyd

Pesticide mixtures can impact pest resistance

One of the major benefits of mixing different pesticides together is potentially delaying the onset of resistance in arthropod insect and mite pest populations. However, greenhouse growers must mix together pesticides with different modes of action, and understand that pesticide mixtures may, in fact, enhance the development of resistance due to the expression of different resistance mechanisms in the pest population.

Benefits of pesticide mixtures

Pesticide mixtures involving insecticides and/or miticides are commonly used by growers to enhance the spectrum of control or regulation when multiple arthropod (insect and mite) pest populations are present simultaneously. Growers can mix together two different pesticides although research has demonstrated that three or more pesticides (even fungicides) may be mixed together in a spray solution.

Pesticide mixtures may enhance the control or regulation of arthropod pest populations due to either synergistic interactions or potentiation between the pesticides mixed together. Synergism refers to the toxicity of a given pesticide being enhanced by the addition of a less or non-toxic pesticide, or compound (e.g. synergist). Potentiation alludes to an enhanced toxic effect on the pest population when mixing two active pesticides together. As with applications of single pesticides, it is extremely important to only mix together pesticides with different modes of action in order to avoid or minimize the potential for resistance developing in the pest population.

Resistance development

Different mechanisms may confer resistance in divergent arthropod pest populations of similar species, and multiple resistance mechanisms may co-exist in certain pest populations. The two primary resistance mechanisms are metabolic and physiological resistance.

Metabolic resistance involves the breakdown or detoxification of the pesticide active ingredient by the arthropod pest through the action of particular enzymes including esterases, glutathione *S*-transferases and mono-oxygenases (mixed function oxidases). Physiological resistance refers to decreased sensitivity of the target site (similar to lock-and-key interaction). In this case, the target site is modified such that it is no longer susceptible to binding by the active ingredient.

Two terms associated with resistance are cross and multiple resistance. Cross resistance involves insensitivity to pesticides with similar modes of action or in the same chemical class due to a single resistance mechanism. Multiple resistance refers to an arthropod pest population that is resistant to pesticides with different modes of action or across chemical classes due to the expression of different resistance mechanisms.

Combining pesticides

Tank mixing or combining pesticides with different modes of action may, in theory, delay resistance developing within arthropod pest populations because the mechanisms required to resist pesticide mixtures may not be wide-spread or exist in pest populations. Furthermore, it may be difficult for individuals in the pest population to develop resistance to several modes of action simultaneously.

Arthropods in the population resistant to one or more pesticides would likely succumb to the other pesticide in the mixture. However, this approach also risks selecting for detoxification mechanisms that may permit survival to both pesticides.

Delaying resistance

The ability of pesticide mixtures to delay or postpone the onset of resistance and complement each other in killing target arthropod pests is based primarily on the following assumptions:

1. Resistance to each pesticide is monogenic (resistance resulting from the expression of a single gene).
2. There is no cross-resistance among individuals in the arthropod pest population to the pesticides used in the mixture.
3. Resistant individuals are rare.
4. The pesticides used in the mixture are equal or similar in persistence (residual activity).
5. Some individuals in the arthropod pest population escape treatment or are not treated.

Furthermore, resistance to each pesticide is recessive so that only homozygous (two identical alleles for a given gene in a diploid cell) individuals are able to survive. However, if resistance is not totally recessive then the rate of resistance development may increase.

It has been proposed that pesticide mixtures may waive the onset or development of resistance more effectively than rotating pesticides with different modes of activity. The reason for this is that if resistance to each pesticide is independent and rare then the associated possibility of resistance to either pesticide is also likely to be rare. The key is heterogeneity (composed of parts of different kinds or dissimilar individuals) of resistance in the arthropod pest population.

The effect of pesticide mixtures is, however, unpredictable because differences in mode of action do not necessarily guarantee a lack of common resistance mechanisms but may only reflect the specificity of the enzymes responsible for detoxification. Furthermore, the effects of pesticide mixtures may vary depending on the arthropod pest population as a result of differences in the species, strain, and even biotype. These differences could be associated with physiology and the resistance mechanisms present in the population. In addition, resistance mechanisms do not respond to "selection pressure" (frequency of application) the same way based on the pesticide being applied. Moreover, some resistance mechanisms may in fact negate the advantages of pesticide mixtures.

Multiple resistance

Greenhouse growers need to understand that pesticide mixtures can also give rise to multiple resistance that may extend across other chemical classes resulting in specific arthropod pest populations being very difficult to manage or regulate. As such, applying pesticides individually by rotating products with different modes of action or that act on different target sites may be a more appropriate strategy.

It is also interesting to note that one pesticide may interfere with the metabolic detoxification of another pesticide. Additionally, an active ingredient may compete for or inhibit the same enzyme (e.g. esterase), which would actually increase the toxicity of the pesticide mixture. For example, pyrethroid insecticides may be synergized by certain organophosphate insecticides.

Certain organophosphate pesticides bind to the active site on the esterase enzyme thus preventing detoxification of the active ingredient in pyrethroid insecticides. This is the primary reason why many companies formulate organophosphate and pyrethroid pesticide mixtures to manage multiple arthropod pest complexes and counteract resistance. Examples include Tame/Orthene TR [fenpropathrin (pyrethroid) and acephate (organophosphate)] and Duraplex TR [chlorpyrifos (organophosphate) and cyfluthrin (pyrethroid)]. However, continued use of these pesticide mixtures may result in resistance to both modes of activity by arthropod pest populations, especially those that have the capacity of developing multiple resistance.

In addition, continual reliance on organophosphate and pyrethroid pesticide mixtures may lead to a reduction in the suppression of the metabolic mechanism associated with detoxification of esterases. The suppression of one mechanism may result in the selection or expression of another mechanism, which may be insensitive to both pesticides in the mixture.

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Scouting Notes

Farm Bill funding to be used for pest control projects

USDA announced that it has allocated $45 million, provided by the 2008 Farm Bill, for early detection and action against plant pests and diseases. Society of American Florists reports that the money will fund more than 200 projects, many of which are of high interest to nursery and greenhouse owners. Some of the projects include:

- Cristi Palmer of the IR-4 program will work with James Buck of the University of Georgia and Steve Jeffers of Clemson University to study gladiolus rust.
- A number of projects focusing on *Phytophthora ramorum* (sudden oak death) will receive significant funding.
- Other projects will look at improving the ability to identify, intercept, survey and predict the arrival of new pests, including new diagnostic tools and outreach to help prevent the spread of invasive pests.

SAF and American Nursery & Landscape Association co-chaired the implementation committee of the Specialty Crop Farm Bill Alliance, and monitored USDA's planning efforts once the Farm Bill was enacted. The Farm Bill specified $12 million in 2009, $45 million in 2010, and $50 million a year thereafter to improve USDA's pest detection and prediction activities. USDA estimates the funding will create or support up to 400 jobs.

For more: Society of American Florists, (800) 336-4743; www.safnow.org.