GROWERTALKS

Pest Management

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Resistance Management

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Resistance management is important in delaying the development of pesticide (in this case, insecticides and miticides) resistance in insect and/or mite pest populations. Resistance management is also important in preserving the effectiveness of currently available products.

Pictured: Pesticide mixtures may enhance selection for resistance of insect pests, such as western flower thrips.

Resistance develops when pesticides with similar modes of action are continually applied to manage insect and/or mite pest populations below plant-damaging levels. It's important to understand that pesticides don't cause resistance; instead, pesticides select for naturally occurring resistance traits in insect and/or mite pest populations by removing susceptible individuals from the population.

Two strategies that may delay the onset of resistance developing in insect and/or mite pest populations are pesticide rotations (alternations/cycling) and pesticide mixtures (combinations).

Pesticide rotations

Pesticide rotations involve alternating pesticides with different modes of action. Pesticide rotations can delay the onset of pesticide resistance developing in insect and/or mite pest populations by exposing individuals to a variety of modes of action. Pesticide rotations can also extend the longevity and long-term effectiveness of pesticides.

Pesticide rotations entail using one mode of action within a generation, early in the growing season, and switching modes of action across subsequent generations. However, the effect of pesticide rotations in delaying the onset of resistance decreases when attempting to manage overlapping generations because of the different life stages (eggs, larvae, nymphs, pupae and/or adults) present simultaneously.

In addition, rotating pesticides with different modes of action will only delay resistance if the pesticides select for different resistance mechanisms (e.g. metabolic detoxification or reduced target site sensitivity). In general, rotating pesticides with different modes of action every two to three weeks or across generations may delay the onset of resistance.

Pictured: Rotating pesticides with different modes of action reduces selection pressure on pest populations.

Pesticide rotations are influenced by the insect and/or mite pest life cycle development time during the growing season, which is affected by temperature. For example, higher temperatures result in a faster development time, leading to increased pesticide applications that can increase the rate at which resistance develops.

A concern associated with pesticide rotations is that insect and/or mite pest populations may possess different resistance mechanisms (e.g. metabolic detoxification or reduced target site insensitivity) to the same pesticide. Furthermore, rotating pesticides with different modes of action won't delay resistance if insect and/or mite pest populations exhibit cross-resistance. Cross-resistance occurs when resistance develops to more than one pesticide, resulting in resistance to other pesticides with the same mode of action because of the presence of a common resistance mechanism, such as metabolic detoxification. The reason for rotating pesticides with different modes of action is based on the frequency or proportion of individuals in an insect and/or mite pest population resistant to one pesticide decreasing when another pesticide with a different mode of action is applied. The frequency of resistant individuals declines in subsequent generations after discontinuing applications of the initial insecticide. Therefore, when the initial pesticide is reintroduced into a pesticide rotation program, a high number of susceptible individuals are killed.

Rotating pesticides with different modes of action reduces selection pressure (when a pesticide application is lethal to some individuals in a pest population, but not others) compared to using only one pesticide successively, resulting in less exposure of individuals in an insect and/or mite pest population to one mode of action.

In addition, rotating pesticides with different modes of action can sustain the effectiveness of pesticides in managing insect and/or mite pest populations. However, the effectiveness of pesticide rotations is affected by the stability of resistance, in which resistance to certain pesticides is retained in future generations despite rotating different modes of action. Consequently, rotation programs need to include several pesticides with distinct modes of action that select for different resistance mechanisms.

An example is a four-pesticide, eight-week rotation program in which four pesticides with different modes of action are applied over an eight-week period. Rotate pesticides across generations not within a generation to avoid selecting for cross-resistance. Therefore, each pesticide should be applied for two weeks before switching to another pesticide with a different mode of action.

Pesticide mixtures

Pesticide mixtures entail mixing or combining two or more pesticides into a single spray solution so that multiple insect and/or mite pest populations are managed simultaneously. Pesticide mixtures may suppress resistance developing to two or more pesticides; however, pesticide mixtures may inadvertently select for cross-resistance. The rate of resistance developing in an insect and/or mite pest population to two or more pesticides in a mixture may be delayed compared to applying pesticides individually and at different times. Nonetheless, resistance to a pesticide mixture may be similar to individual applications of the pesticides.

Pesticide mixtures can increase the rate of resistance to multiple active ingredients, especially if insect and/or mite pest populations have more than one resistance mechanism. In addition, pesticide mixtures will only be effective in

delaying resistance if the pesticides have similar persistence (residual activity) and insect and/or mite pest populations don't exhibit cross-resistance to the pesticides used in the mixture.

Which strategy is best for resistance management?

Pesticide mixtures, when each pesticide is applied at the label rate, may be more effective than pesticide rotations in delaying resistance. However, pesticide mixtures may have issues associated with: 1) cost; 2) amount of active ingredient applied; and 3) unintended consequences related to targeting different insect and/or mite pests that cause damage at different times during the growing season.

For example, pesticide mixtures may increase selection for resistance because populations of insect and/or mite pests not causing damage may be exposed to pesticide applications targeting another insect and/or mite pest population. In addition, pesticide mixtures may select for mechanisms of resistance (e.g. metabolic detoxification or reduced target site sensitivity) that are present in insect and/or mite pest populations. Therefore, pesticides that are mixed together should not only have different modes of action, but also target different resistance mechanisms.

Pesticide rotations are easier to implement and are commonly used because pesticide mixtures must abide by certain criteria to be effective in resistance management, such as mixing pesticides with different modes of action and similar persistence (residual activity). Consequently, pesticide rotations may be more effective in delaying resistance than pesticide mixtures. As such, the Insecticide Resistance Action Committee (IRAC) recommends rotating pesticides with different modes of action as the most practical resistance management strategy. **GT**

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