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Mixed Up About TANK MIXING?

Tank mixing insecticides and miticides does not have to be confusing. Here are the essentials you need to know before you mix.

Text and photos by Raymond A. Cloyd

The continual losses or changes in registration of "older," broad-spectrum pesticides due to federal rules and regulations — and manufacturers' voluntary withdrawals or cancellations — has led to an increase in the development and availability of alternative pesticides that are more selective in the types of arthropod pests (insects and mites) controlled. That is, these alternative pesticides control a narrow spectrum of insect and/or mite pests. Alternative pesticides include insect growth regulators, insecticidal soaps, horticultural oils, selective feeding inhibitors and microbial agents (entomogenous bacteria, fungi and related microorganisms). Many of these alternative pesticides have minimal direct and/or indirect impact on natural enemies, including parasitoids and predators.

Although the availability of pesticides that demonstrate specificity may be desirable, there is a dilemma when dealing with multiple insect and/or mite pests in greenhouses and nurseries. In order to regulate or control the myriad pests that feed on ornamental crops in greenhouses and nurseries, growers can tank mix several alternative pesticides in order to expand the activity of the application. For example, thrips, whiteflies and spider mites are common arthropod pests of both greenhouses and nurseries. As such, it may be necessary to tank mix two (possibly more) pesticides in order to obtain the same spectrum of control for all three arthropod pests that a single, broad-spectrum pesticide might provide.

What is tank mixing? Tank mixing involves combining two or more pesticides into a single spray solution. This procedure is popular because of the potential for improved pest control in most instances. While there are many benefits to tank mixing, there are several problems that need to be considered before tank mixing any pesticides.

Ask yourself, "Why am I mixing these pesticides?" It is important to develop tank mixtures that make sense. For example, tank mixing two pesticides that have miticidal properties, such as abamectin (Avid) and bifenazate (Floramite), is not recommended because both are active on twospotted spider mite *(Tetranychus urticae)* adults. Tank mixing abamectin with clofentezine (Ovation SC) or etoxazole (TetraSan 5 WDG), however, is appropriate because clofentezine or etoxazole will control the eggs, larvae and nymphs. This tank mixture makes sense; it targets all life

Azadirachtin (Azatin) is more effective when tank mixed with the entomopathogenic fungus *Beauveria bassiana* (BotaniGard) because azadirachtin slows the molting process of the target pest, allowing the fungus to penetrate the pest and initiate an infection.

Research shows that mixing the insecticide spinosad (Conserve) with the imidacloprid (Marathon), abamectin (Avid) or bifenazate (Floramite) does not negatively affect the ability of spinosad to control Western flower thrips.

stages of the twospotted spider mite.

So why mix pesticides together? One reason is convenience. It is less time-consuming, costly and labor-intensive to mix together two or more pesticides into a single spray solution and then perform one spray application as opposed to making two or more applications.

Synergistic mixes. Another reason for tank mixing is the potential for improved pest control or enhanced effectiveness. Tank mixing two pesticides may result in greater mortality of insect or mite pests than if either pesticide were used separately. This technique is referred to as synergism or potentiation — the enhancement of efficacy. For example, research has demonstrated that tank mixing two different pesticides results in higher mortality of insect pests, such as Western flower thrips *(Frankliniella occidentalis)* and certain whitefly species, than when the pesticides are applied separately.

Studies have also demonstrated that insecticides containing the active ingredient azadirachtin (Azatin, Ornazin) and the entomopathogenic fungus *Beauveria bassiana* (BotaniGard, Naturalis) are more effective when tank mixed compared to when applied individually. Why is this so?

Western flower thrips, shown here feeding on a chrysanthemum leaf, can often be controlled better by combining pesticides in a tank mix.

Azadirachtin may actually "stress" insects, thus enhancing the efficacy of the entomopathogenic fungus. During the summer months, insect pests — such as thrips and aphids — molt or shed their skins (cuticles) so rapidly that entomopathogenic fungi are not able to penetrate the insect. The insect sheds off the spore-forming conidia along with the old skin. But tank mixing azadirachtin with *B. bassiana* results in synergism because the insect growth regulator azadirachtin slows the molting process, allowing the fungus to penetrate the target insect pest and initiate an infection.

Some compounds are strictly referred to as synergists. For example, piperonyl butoxide (also called PBO), which inhibits an insect or mite pest's ability to break down toxins, may be mixed with pyrethroid-based pesticides — including bifenthrin (Talstar), cyfluthrin (Tempo, Decathlon 20 WP) and fenpropathrin (Tame 2.4 EC) in order to block enzymes present in insects that are capable of breaking down the active ingredient so that it no longer has insecticidal properties. Another procedure that may be used to enhance efficacy is to mix a pyrethroid-based pesticide with a different type of pesticide. In theory, the pyrethroid-based pesticide will irritate insect or mite pests, increasing their activity and thus their exposure to any spray residues.

Just as synergism improves the efficacy of two or more pesticides, the opposite, which is referred to as antagonism, may also occur. Antagonism occurs when two

More on the author's research

For more information on the studies that were designed to assess the influence of tank mixtures on the efficacy of insect or mite pests, refer to the following articles:

- Cloyd, R.A., C.L. Galle, and S.R. Keith. 2007. "Greenhouse pesticide mixtures for control of silverleaf whitefly (Homoptera: Aleyrodidae) and twospotted spider mite (Acari: Tetanychidae)." *Journal of Entomological Science*. 42(3): 375-382.
- Warnock, D.F., and R.A. Cloyd. 2005. Effect of pesticide mixtures in controlling Western flower thrips (Thysanoptera: Thripidae). *Journal of Entomological Science*. 40(1): 54-66.

The proper combination of pesticides in a tank mix can aid in killing all life stages of pests. However, the opposite can also be true. For instance, buprofezin (Talus 40SC) plus chlorfenapyr (Pylon) for controlling whiteflies will actually result in decreased mortality rates.

or more pesticides are mixed, and the resulting combination is less effective than when the pesticides are applied individually. In other words, the mixture is less successful, based on percent mortality, than separate applications of each pesticide. In addition to a reduction in effectiveness, there is also the potential for plant injury, or phytotoxicity. Be sure to read the label prior to tank mixing pesticides because pesticide labels generally state which materials can and cannot be tank mixed. If questions arise, contact the manufacturer of the pesticide for information.

Additional considerations with tank mixing. Another issue with tank mixing is incompatibility, which is a physical condition that prevents pesticides from combining properly in a spray solution. This problem may result in decreased effectiveness or phytotoxicity. Incompatibility may be due to the chemical or physical nature of the pesticide(s), impurities in the water, water temperature or the types of formulations mixed together.

In order to determine compatibility between two or more pesticides, a "jar test" should be conducted. Collect a sample of the spray solution (such as 1 pint) into an empty container, and allow the solution to "sit" for approximately 15 minutes. If the pesticides are not compatible, there may be a noticeable separation or layering, or precipitates, such as flakes or crystals, may form. If the pesticides are compatible, then the solution may appear homogeneous or resemble milk.

The issue of tank mixing and resistance is not well-understood, although it is thought that applying two or more pesticides at different intervals has the same advantages as a tank mixture. However, this idea is not entirely true because each individual insect or mite pest in the population does not receive a lethal dose or concentration of each pesticide, and as a result, resistance may evolve more rapidly than with a tank mixture. The mechanisms required to resist the tank mixture may not be widespread or exist in the population. In addition, insect and/or mite pests in the population resistant to one pesticide would likely succumb to the other pesticide in the tank mixture. It should be noted that the ability of insect and/or mite pest populations to evolve resistance depends on previous exposure to either similar or different modes of action.

An additional concern with tank mixing pesticides is that as new plant varieties become available, there may be differences in tolerance to tank mixtures, based on varietal sensitivity. In order to avoid any problems associated with phytotoxicity, it is best to test a pesticide mixture on a sample of plants (approximately 10) prior to applying to the entire crop.

Tank mixing abamectin (Avid) with clofentezine (Ovation SC) or etoxazole (TetraSan 5 WDG) controls adult two-spotted spider mites, as well as the eggs, larvae and nymphs.

Further research. My research at Kansas State University, Manhattan, has evaluated the effect of tank mixing pesticides on efficacy against Western flower thrips, twospotted spider mite and sweetpotato whitefly B-biotype *(Bemisia tabaci).* One study demonstrated that mixing the insecticide spinosad (Conserve SC) with the other pesticides evaluated (imidacloprid [Marathon], abamectin and bifenazate) did not negatively affect the ability of spinosad to control Western flower thrips.

In another study, the effect of mixing the pesticides buprofezin (Talus 40SC), acetamiprid (TriStar), chlorfenapyr (Pylon) and bifenazate were evaluated in two-, three- and four-way mixtures on the control of both twospotted spider mite and sweetpotato whitefly B-biotype. Most of the tank mixtures did not affect control of either arthropod pest. However, the buprofezin plus chlorfenapyr, as well as acetamiprid plus chlorfenapyr plus bifenazate, resulted in a lower percentage of sweetpotato whitefly B-biotype nymphal mortalities (less than 38 percent) than the other tank mixtures.

In conclusion, the myths and realities of tank mixing can be argued from both a positive and negative perspective. Although there are substantial advantages to tank mixing, such as synergism, it is important to be cautious when tank mixing in order to avoid problems associated with antagonism, incompatibility and phytotoxicity.

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