Tank-Mixing and Pesticide Performance

New research from the University of Illinois answers questions about tank mixing efficacy on western flower thrips.

By Ray Cloyd and Daniel Warnock

Western flower thrips adult. (Photo courtesy of Ray Cloyd)

Insecticides and miticides are used by greenhouse producers to control many of the major arthropod pests. Western flower thrips (WFT) is one of the most important insect pests in greenhouses because it directly damages plant leaves and flowers. In addition, WFT indirectly damages plants by vectoring tospoviruses — impatiens necrotic spot virus and tomato spotted wilt virus — which result in economic loss, as infected crops must be destroyed.

In general, greenhouse managers deal with WFT by applying insecticides on a schedule. However, WFT is typically not the only arthropod pest that greenhouse managers encounter, especially when different crop types are being grown simultaneously. This often leads to a complex array of insect and mite pests occurring in a greenhouse simultaneously. As a result, greenhouse managers rely on the use of insecticides and miticides to manage these pest complexes.

A current trend in the greenhouse industry is the loss of older, conventional pesticides including insecticides and miticides that kill a broad-range of insect and mite pests. This loss has led to the registration of pesticides with a narrow range of pest activity or selectivity. These are often referred to as biorational pesticides. However, in order to continually manage the diversity of arthropod pests, greenhouse managers mix together or "tank mix" several biorational pesticides to broaden the spectrum of activity of the application.

The primary benefit of tank mixing is a reduction in the number of applications, thereby decreasing labor costs. In addition, tank mixing two pesticides may result in greater mortality of insect or mite pests than if either pesticide were used separately. This is often referred to as synergism, which may be due to one pesticide interfering with the insect's ability to detoxify the second pesticide. Another potential benefit of tank mixing is that it may delay the development of resistance in insect populations.

Despite the initial benefits of pesticide mixtures, problems may occur when two or more pesticides are mixed together. These include increasing the probability of insect or mite resistance to multiple pesticides, potential plant injury (phytotoxicity) and pesticide incompatibility. An even greater concern is antagonism. This occurs when the mixing of two or more pesticides results in lower pest mortality than if the pesticides were applied separately.

Although studies have been conducted on the effects of tank mixes in controlling agricultural pests, there is little information to support or refute claims of antagonism or synergism for greenhouse insect or mite pests. It is important to determine if mixtures of two or more pesticides result in reduced efficacy so we can avoid having greenhouse managers make unnecessary pesticide applications, thus increasing production costs and worker exposure to pesticide residues.

The purpose of this study was to determine if mixtures of biorational pesticides that are labeled for and used to control thrips, spider mites, whiteflies, leafminers and aphids in greenhouses results in reduced efficacy in controlling WFT.

Figure 1. Pesticides and the recommended-label rates used to assess the effect of tank mixing on control of western flower thrips, Frankliniella occidentalis, *in the laboratory and greenhouse experiment. The maximum recommended-label rate was applied when the pesticide was specifically labeled for western flower thrips.*

Pesticide Common name	Trade name	Label rates	Rate used for experiments
Spinosad	Conserve	6.0-11.0 fl.oz. per 100 gal.	0.1 fl.oz./1 gal.
Bifenazate	Floramite	8.0 fl.oz. per 100 gal.	0.1 fl.oz./1 gal.
Abamectin	Avid	8.0 fl.oz. per 100 gal.	0.1 fl.oz./1 gal.
imidacloprid	Marathon	1.7 fl.oz. per 100 gal.	0.02 fl.oz./1 gal.
Water control	—	—	—

MATERIALS AND METHODS

Four pesticides commonly used in production greenhouses to manage greenhouse pests, including WFT, were screened in a laboratory and greenhouse experiment to determine if two-, three- and four-way combinations had any synergistic or antagonistic effects in controlling WFT.

To assess pesticide compatibility for both experiments, a jar test was conducted for each pesticide and mixture. A spray solution volume of 6 fl.oz. of each pesticide and all possible mixtures was sprayed into a 7-fl.oz. jar. The jars were tightly sealed, placed into a laboratory and visually evaluated for layering, precipitate formation and settling 0, 2, 4 and 20 hours after mixing.

Experiment 1: Effect of pesticide mixtures on WFT mortality in a

greenhouse. A completely randomized design was used with six replications per treatment. Treatments were the pesticides spinosad (Conserve, Dow AgroSciences), bifenazate (Floramite, Crompton/Uniroyal Chemical Corp.), abamectin (Avid, Syngenta Professional Products, Inc.) and imidacloprid (Marathon, Olympic Horticultural Products) applied separately and in all possible mixtures.

Cut stems of transvaal daisy, *Gerbera jamesonii* were obtained from a commercial supplier. Stems were cut to a uniform length (almost 12 inches), pulse treated with a floral preservative solution (9.5 g per L^{-1} deionized water) to enhance vaselife and graded to a uniform flower size. Individual stems were inserted through a plastic lid covering a 946 ml clear plastic cup filled with floral preservative and placed inside an empty 5-inch pot. The space between the cup and pot was filled with SB300 Universal soilless growing medium to stabilize the cup and support a screened isolation cage. The cut flowers were isolated from unwanted WFT migration. The caged flowers were placed in a greenhouse with night temperatures set at 66-68° F and day temperatures at 75-84° F under natural daylight conditions. Each flower was inoculated with 25 WFT adults (mixture of females and males) from a laboratory colony. After inoculation, the chambers were sealed to the pots with 2-inch-wide clear packing tape to isolate each flower while still allowing all the flowers to be exposed to the greenhouse environment.

Western flower thrips were allowed to establish on the flowers for 48 hours before the flowers were treated with one of the four pesticides and all possible mixtures. The pesticides were prepared based on the label-recommended rates (see Figure 1, left). Almost 1 oz. of each pesticide and mixture was applied to the upper and lower surfaces of the inoculated flowers using a 1-gal. compressed air sprayer. Three ½-inch holes in the screened cage, each sealed, provided ports to insert the sprayer nozzle and apply the designated treatments. Experimental controls were a water spray and an untreated check. The number of live WFT was assessed 72 hours after treatment by dissecting the flower, and counting the number of live WFT. Data from the flowers treated with the pesticides were analyzed in a one-way analysis of variance (ANOVA), and significant treatment means were separated using Fisher's protected least significant difference (LSD) test.

Experiment 2: Effect of pesticide mixtures on WFT mortality in laboratory bioassay. A leaf assay was conducted under laboratory conditions to assess the relative tolerance of WFT to the selected pesticides and all possible mixtures. The experiment was set up as a completely randomized design with six replications spaced over time. Pesticide treatments were the same as the first experiment. Pesticides were prepared based on the recommended-label rates (see Figure 1, left). Treatments were conducted separately and in all possible mixtures. Controls consisted of water-sprayed and untreated leaves.

The assay units consisted of individual cells of a clear high impact polystyrene (HIPS) insect rearing tray. Individual rearing tray cells were half-filled with warm agar as a moisture source.

Pesticide-free leaf disks of chrysanthemum, *Dendranthema grandiflora*, were sealed to the warm agar thereby preventing WFT from migrating under the leaf disks after inoculation. To mitigate any degradation of the pesticide treatments, the agar was allowed to cool for 30 minutes after the leaf disks were embedded. A 2 x ½-inch diameter tube was used to direct the pesticide treatments into each individual cell in order to minimize cross contamination between the tray cells. Approximately .03 fl.oz. of each treatment solution was applied with a hand-held spray bottle to the individual tray cells containing a leaf disk. This volume was sufficient to completely saturate the agar, leaf disk and tray sides.

Immediately after applying one of the 15 pesticide and two control treatments, individual cells were inoculated with 15 WFT adults (mixture of females and males) collected from the laboratory colony. Two-day-old adult WFT were anesthetized with carbon dioxide for 30 seconds, placed on the center of each treated leaf section and counted to ensure that 15 WFT had been applied. To prevent WFT from drowning, pesticide residues on the agar surface were absorbed using a Kimwipe. Tray cells were immediately sealed with a vented cover and placed inside a growth chamber at 79-82° F and a 14:10 (L:D) photoperiod. The number of live WFT was assessed after 48 hours. Data were analyzed ➧

Figure 2. Effect of pesticide mixtures on western flower thrips (WFT), Frankliniella occidentalis, *in the greenhouse experiment based on the mean number of live WFT found in Transvaal daisy flowers. Treatments: B=bifenazate (Floramite), S=spinosad (Conserve), A=abamectin (Avid) and I=imidacloprid (Marathon).*

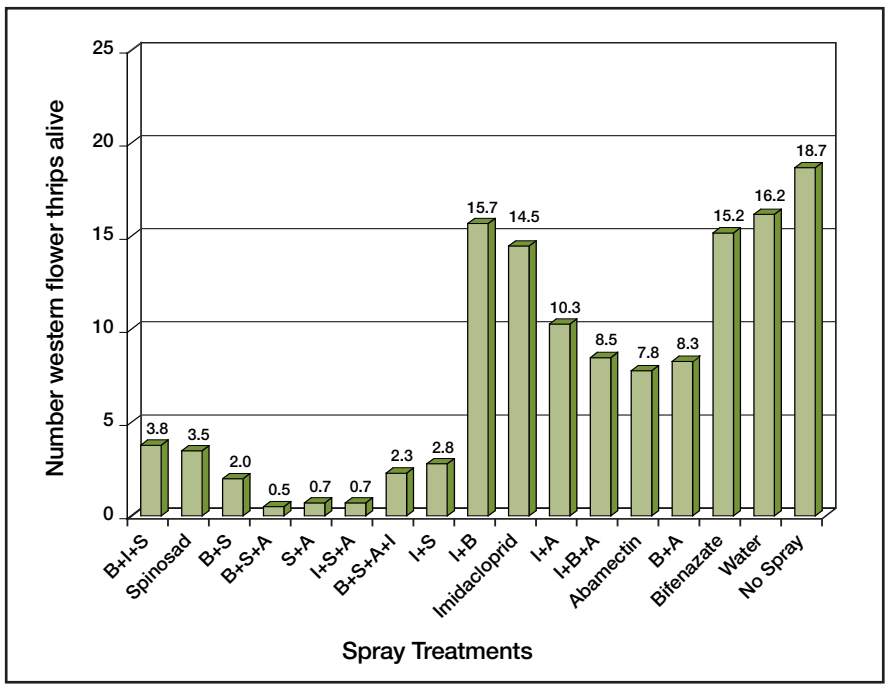
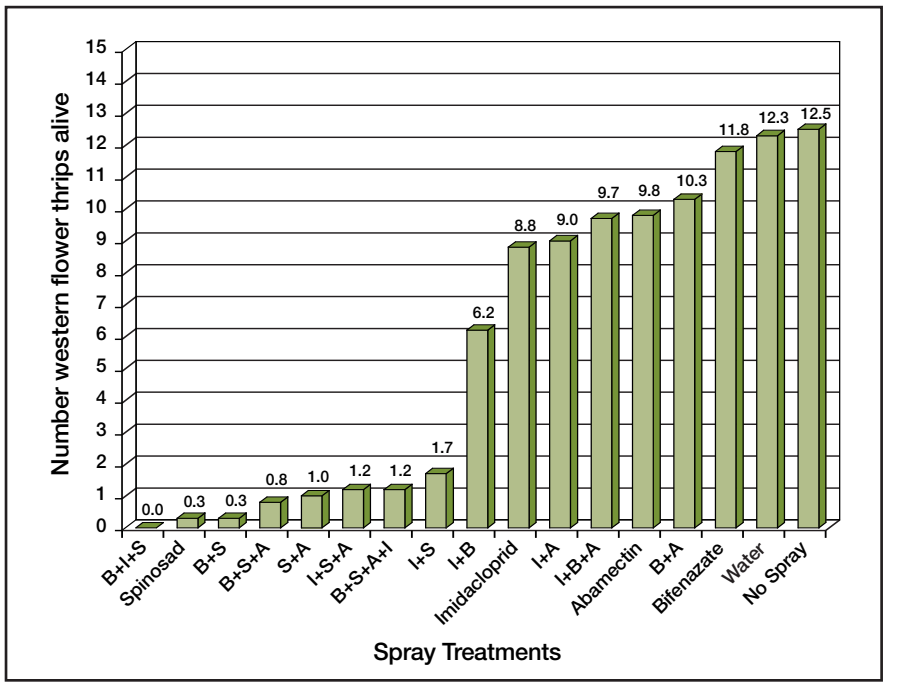


Figure 3. Effect of pesticide mixtures on western flower thrips (WFT), Frankliniella occidentalis, *in the laboratory bioassay experiment based on the mean number of live WFT found in tray cells containing a chrysanthemum,* Dendranthema grandiflora *leaf disk. Treatments: B=bifenazate (Floramite), S=spinosad (Conserve), A=abamectin (Avid) and I=imidacloprid (Marathon).*



in ANOVA, and significant treatment means were separated using Fisher's protected LSD test.

RESULTS AND DISCUSSION

The jar tests for the experiments did not indicate any incompatibility based upon the lack of layering or precipitates 0, 2, 4 and 20 hours following mixing. This suggests that all the treatment mixtures were compatible with each other.

Experiment 1: Effect of pesticide mixtures on WFT mortality in a greenhouse. Treatment significantly affected the number of live WFT recovered from transvaal daisy flowers. Based on the number of live WFT recovered, treatments with Conserve and Avid, in general, had the greatest mortality (see Figure 2, page 35). Additionally, the Conserve + Avid tank mix resulted in significantly fewer live WFT recovered than the Conserve and Avid individual applications. This suggests a synergistic effect when these two pesticides are mixed together. In this experiment, we didn't discover any treatments with antagonistic effects. For example, Floramite + Marathon when tank mixed with Conserve + Avid did not affect mortality based on the numbers of live WFT recovered (see Figure 2, page 35).

Experiment 2: Effect of pesticide mixtures on WFT mortality in laboratory bioassay. Treatment significantly affected the number of live WFT recovered from the chrysanthemum leaf disks. All the treatments with Conserve, including the individual treatment and tank mixes, were significantly different from the water control, untreated check and all the other treatments in the number of live WFT recovered from the leaf sections (range: 0.0-1.7). However, none of the Conserve treatments were significantly different from each other based on the number of live WFT recovered (see Figure 3, page 35).

As in the greenhouse experiment, both the Floramite and Marathon individual treatments were not significantly different from the water control and untreated check in the numbers of live WFT recovered (see Figure 3, page 35). This was expected, as both pesticides are not recommended for WFT control based on the manufacturers' labels. However, it should be noted that the mixture with these

Top: *Transvaal daisy flowers in isolation cages to be sprayed with various combinations of pesticides.* ***Middle****: Rearing tray cells half-filled with agar and containing a treated chrysanthemum leaf disk and WFT.* ***Bottom****: Counting the number of live and dead WFT. (Photos courtesy of Daniel Warnock)*

two pesticides resulted in significantly fewer live WFT recovered than when the two pesticides were applied separately.

Studies evaluating pesticide mixtures have been primarily conducted in laboratory environments topically applying mixtures to insects, using a leaf-dip bioassay, injecting mixtures into insects (Yes…really!) or incorporating mixtures into diet assays. However, few studies have been conducted in field situations. In our study, we evaluated pesticide mixtures in a greenhouse environment. Based on our results, it appears that mixtures of Conserve with any of the other pesticides tested do not affect the ability of Conserve to control WFT. This information is important to greenhouse managers who want to tank mix pesticides and still control WFT along with other plant-feeding insects and mites found in greenhouses. GPN

Raymond A. Cloyd is assistant professor and extension specialist in Ornamental Entomology/Integrated Pest Management and Daniel F. Warnock is assistant professor at the University of Illinois Department of Natural Resources and Environmental Sciences. They can be reached by phone at (217) 244-7218 or E-mail at rcloyd@uiuc.edu.

LearnMore
For more information related to this article, go to www.gpnmag.com/lm.cfm/gp080403