Getting Stirred Up About Tank Mixing

Tank mixing has many benefits, though certain problems may occur. Read on to learn how tank mixing selected insecticides and miticides affects their ability to control silverleaf whitefly and twospotted spider mite.

By Raymond Cloyd, Cindy Galle and Stephen Keith

Sweet potato whitefly B-biotype, Bemisia tabaci, *adult. (Photos: Raymond Cloyd)*

The silverleaf whitefly, *Bemisia argentifolii* (which is synonymous with the sweet potato whitefly, *Bemisia tabaci* B biotype) and the twospotted spider mite, *Tetranychus urticae*, are major arthropod pests in greenhouses. Silverleaf whitefly and twospotted spider mite can cause extensive damage and economic loss if populations are not managed in a timely manner. Greenhouse producers typically use pesticides to control these pest species. However, to increase the activity of spray applications and manage the diversity of insect and mite pests, growers typically mix different insecticides and miticides.

Mixing Pesticides

Tank mixing involves combining two or more pesticides into a single spray solution, which reduces the number of applications and decreases labor costs. Mixing two or more pesticides may result in synergism or potentiation, which means there may be greater pest mortality than if either pesticide were applied individually. Pesticide mixtures may also be more effective on certain developmental stages of insect and mite pests. Previous research has demonstrated that mixing two insecticides increases efficacy against insect pests such as western flower thrips, *Frankliniella occidentalis* and whiteflies compared to when each pesticide is applied separately.

Although there are benefits of pesticide mixtures, problems may occur when two or more pesticides are mixed together, such as plant injury (phytotoxicity) and pesticide incompatibility. However, a greater concern is antagonism, in which mixing two or more pesticides results in decreased pest mortality compared to efficacy when pesticides are applied separately.

Previous Research

Previous studies involving the control of insect pests using pesticide mixtures have been primarily conducted on lepidopteran larvae including the beet armyworm (*Spodoptera exigua*), cotton leaf-

Pesticide Information

Common name	Trade name	Company	Label rate	Experiment rate
Buprofezin	Talus	SePro Corp.	7.7 oz./379 liter	0.601 ml. per liter
Acetamiprid	TriStar	Cleary Chemical Corp.	20 g./379 liter	0.052 g. per liter
Chlorfenapyr	Pylon	OHP	2.6 fl.oz./379 liter	0.203 ml. per liter
Bifenazate	Floramite	Chemtura	6 fl.oz./379 liter	0.468 ml. per liter

Figure 1. Pesticides and the recommended label rates used to assess the effect of tank mixing on control of silverleaf whitefly and twospotted spider mite under greenhouse conditions.

worm (*Spodoptera littoralis*), European corn borer (*Ostrinia nubilalis*) and tobacco budworm (*Helicoverpa virescens*). Relatively minimal, if any, information is available on the effect of pesticide mixtures in controlling greenhouse insect and mite pests such as the silverleaf whitefly and twospotted spider mite.

Research conducted at the University of Illinois reported that combinations of Conserve (spinosad), an insecticide used by greenhouse producers to control western flower thrips, with other pesticides labeled for control of twospotted spider mite and whiteflies did not affect the efficacy of spinosad in controlling western flower thrips. However, there are no reported studies demonstrating the effects of the same pesticides in mixtures against two different insect or mite pests.

This study's objective was to determine if mixtures of selected pesticides labeled for control of the silverleaf whitefly and twospotted spider mite result in reduced or enhanced efficacy or efficacy that remains the same against both pests.

Materials And Methods

Two experiments were conducted to determine whether tank mixing selected insecticides and miticides affects their ability to control silverleaf whitefly and twospotted spider mite. The four pesticides evaluated were Talus (buprofezin), TriStar (acetamiprid), Pylon (chlorfenapyr) and Floramite (bifenazate). Buprofezin and acetamiprid are labeled for control of silverleaf whitefly, whereas chlorfenapyr and bifenazate are labeled for control of twospotted spider mite.

Silverleaf Whitefly Experiment

Seventy-five *Salvia x superba* were transplanted into 0.94-liter containers in a growing medium (Metro-Mix 700) consisting of 50-60 percent composted pine bark, 20-30 percent Canadian sphagnum peat moss, 5-15 percent medium-grade horticultural vermiculite and 5-15 percent horticultural perlite. No pesticides were applied to test plants before conducting the experiment. Test plants were fertilized after planting with 5 grams of 14-11.6-6.1 (N-P-K) Osmocote granular fertilizer. The test plants were placed in a greenhouse-maintained silverleaf whitefly colony to initiate an infestation.

Silverleaf whitefly populations were sustained on poinsettia (*Euphorbia pulcherrima*) and speedwell (*Veronica officinalis*) plants enclosed in an infestation chamber. The silverleaf whiteflies were originally obtained from Bohn Nursery and AllTech Research and Development. The whiteflies in the colony were identified as silverleaf whitefly or sweet potato whitefly B biotype by Frank Byrne, Department of Entomology, University of California, Riverside.

The enclosed chamber was 6½ ft. wide and roughly 16½ ft. long with an A-frame roofline measuring 56 inches at point with roughly ➧

Silverleaf Whitefly Results

Treatment*	7 Days After Treatment		14 Days After Treatment	
	Total WFN	PMORT WFN	Total WFN	PMORT WFN
BU	108	17de**	136	77abc**
AC	267	18cde	103	36cd
CH	267	2e	276	7d
BI	136	44bcd	311	7d
BU + CH	103	46bcd	74	37bcd
BU + BI	194	30bcde	115	81a
AC + CH	117	28bcde	96	86a
AC + BI	106	81a	65	86a
AC + BU + CH	227	50bc	92	88a
AC + BU + BI	180	52b	82	76ab
AC + CH + BI	262	31bcde	154	35cd
Untreated Check	538	1e	919	0d
Water control	737	2e	962	3d

*Treatment designations: BU=buprofezin, AC=acetamiprid, CH=chlorfenapyr and BI=bifenazate.
**Means within a column followed by a common letter are not significantly different (P=0.05) as determined by Tukey's standardized range (HSD) test.

Figure 2. Total number of silverleaf whitefly nymphs (WFN) per treatment and percent nymphal mortality (PMORT WFN) for four pesticides and pesticide mixtures seven and 14 days after treatment; n=5.

Sweet Potato Whitefly Nymphal Mortality

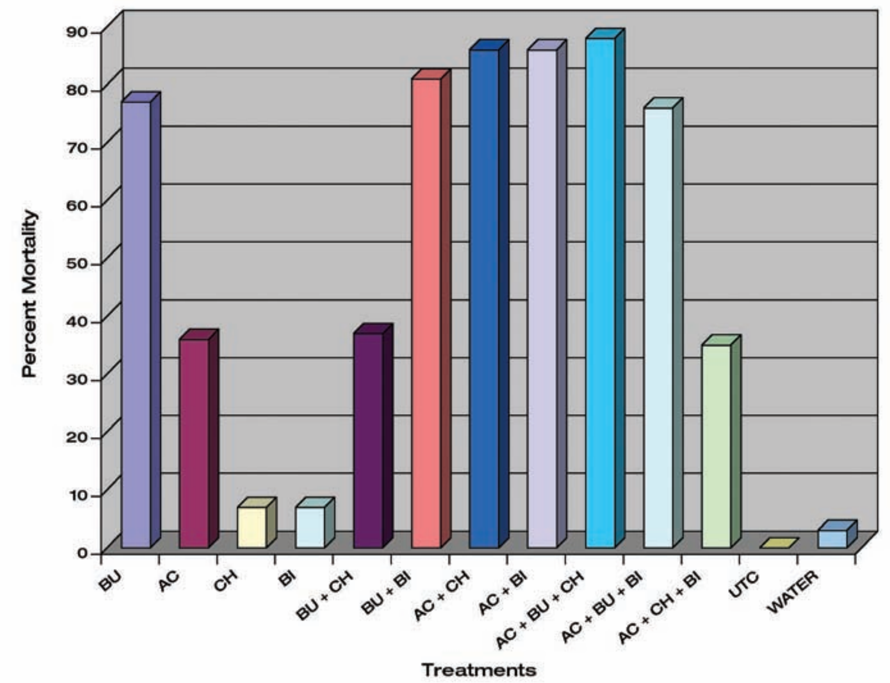

*Figure 3. Percent nymphal mortality of sweet potato whitefly B biotype (*Bemisia tabaci*) for all four pesticides and pesticide mixtures 14 days after treatment.*

36-inch-tall sides. There was a single wire-mesh bench in the chamber. The bench height from the floor was roughly 36 inches.

The roof and ends were covered with clear 8-mm corrugated polycarbonate, and the sides and bottom were covered with antivirus insect screening 50x24 (0.2x0.8 mm) obtained from GreenTek. The sides were rolled up and secured with Velcro when closed. The poinsettia and speedwell plants, obtained from H. M. Buckley and Sons and AllTech Research and Development, were rotated and replaced with fresh plants approximately every two weeks to maintain the silverleaf whitefly colony which at the time the experiment was initiated was six months old.

Based on daily observations, we allowed the test plants to remain in the chamber for approximately 10 days to obtain a similar cohort of silverleaf whitefly nymphs. Once the test plants were infested, each plant was removed from the chamber and individual, 2-way and 3-way treatment combinations were applied. The pesticides and rates used are shown in Figure 1, page 32. There were 11 pesticide treatments, which included the individual, 2-way and 3-way treatments with five replications per treatment. There was also an untreated check and water control.

The test plants were about 5 inches tall, and the number of silverleaf whitefly nymphs was approximately 3 per sq.cm. of leaf tissue at the time of application. Each plant's upper and lower leaf surfaces were thoroughly sprayed with a fine mist to ensure all whitefly nymphs present were in contact with the spray solution.

Applications were made using a carbon dioxide backpack sprayer. After the appropriate treatments had been applied, each replicate (plant) was individually placed into a wire-mesh cage (12x30 inches) covered with the same anti-virus insect screening as the infestation chamber. Test plants were then placed into a greenhouse on a wire-mesh raised bench and arranged in a completely randomized design. Environmental conditions in the greenhouse ranged from 72-88° F and 70-80 percent relative humidity (RH). Test plants received natural illumination during the experiment and were irrigated as needed with a handheld sprinkler; no overhead irrigation was used.

Plants were evaluated before application and seven and 14 days after treatment. Five leaves were randomly selected and harvested from each replicate. The numbers of live and dead whitefly nymphs were recorded. Based on previous observations, there were no escapes (live nymphs crawling or dead nymphs falling off plants).

Spider Mite Experiment

Seventy-five African marigold, *Tagetes erecta*, plugs were transplanted into 0.47-liter containers in a growing medium consisting of 35-percent peat, 45-percent aged pine bark, 15-percent aged rice hulls and 5-percent composted hardwood. No pesticides were applied to the test plants before conducting the experiment.

The plants were placed on a flood floor table in a greenhouse. The flood floor system was a ➧

Netafim flood mat programmed for two 10-minute cycles during a 24-hour period. This system was used to maintain our twospotted spider mite colonies on African marigold and butterfly bush (*Buddleia spp.*).

Leaves from marigold plants infested with twospotted spider mites (larvae, nymphs and adults) were removed and placed onto the test plants on two consecutive days to help ensure the nymphs and adults would be evenly distributed on the test plants.

Once the test plants were infested with twospotted spider mites, treatments were applied. The plants were approximately 4 inches tall at application time. We used the same application equipment as in the first experiment.

Following application of all treatments, the plants were placed in a greenhouse on a wire-mesh raised bench equipped with a flood floor system in a completely randomized design with one plant equivalent to one replicate. The flood floor system prevented the twospotted spider mites from migrating onto other test plants.

There were 11 treatments with five replications per treatment, which included the individual, 2-way and 3-way treatments. There was also an untreated check and water control. Environmental conditions inside the greenhouse during the experiment ranged from 72 to 86º F and 40-80 percent RH. Plants received natural illumination for the duration of the experiment and the same watering regime as the first experiment.

Plants were evaluated before application and seven and 14 days after treatment. Five leaves were randomly selected from each replicate. The numbers of live and dead twospotted spider mite nymphs were counted and recorded. As with the whitefly experiment, there were no escapes.

Results

For both experiments, data were subject to an analysis of variance (ANOVA) with treatment as the main effect. Percent mortality for each treatment was calculated by dividing the number of dead silverleaf whitefly or twospotted spider mite nymphs by the total number of nymphs for each pest recovered per plant. Percent mortality values were normalized by arscine square-root transformation and subject to a 1-way analysis of variance with treatment as the main effect. Significant mean percent mortality values for the treatments were separated using a Tukey's standardized range (HSD) test.

For the silverleaf whitefly experiment, there was no statistical difference among treatments before application. There was a significant difference in percent whitefly nymphal mortality seven and 14 days after treatment (see Figure 2, page 34).

For the twospotted spider mite experiment, there was no statistical difference among treatments before application. Percent nymphal mortality was significantly different seven and 14 days after treatment (see Figure 4, page 38).

Twospotted spider mite, Tetranychus urticae, *adult.*

Discussion

The pesticide mixtures, in general, were not antagonistic based on the percent mortality values of silverleaf whitefly nymphs 14 days after treatment, with most of the mixtures resulting in greater than 75 percent mortality; however, the buprofezin and chlorfenapyr mixture and the acetamiprid, chlorfenapyr and bifenazate mixture provided insufficient control of silverleaf whitefly nymphs (37 and 35 percent mortality, respectively) (see Figure 2, page 34).

The individual applications of acetamiprid and bifenazate resulted in significantly lower percent mortality values of silverleaf whitefly nymphs seven days after treatment (18 and 44 percent, respectively) than the mixture (81 percent), which suggest potential synergistic or additive effects when these two pesticides were mixed together.

The buprofezin and chlorfenapyr mixture may have been antagonistic 14 days after treatment based on the difference in percent mortality values of silverleaf whitefly nymphs between the single buprofezin treatment (77 percent) and the mixture (37 percent). Both chlorfenapyr and bifenazate provided minimal control of silverleaf whitefly nymphs with percent mortality values less than or equal to 7 percent (see Figure 2, page 34), which was not surprising because neither pesticide is registered for use against the silverleaf whitefly.

None of the pesticide mixtures appeared to be antagonistic in controlling twospotted spider mite, with greater than or equal to 90 percent nymphal mortality seven days after treatment for four of the mixtures and 100-percent nymphal mortality for all of the mixtures 14 days after treatment (see Figure 4, page 38). Moreover, there were no live twospotted spider mite nymphs present on any of the plants treated with the mixtures as well as the plants that received the individual applications of chlorfenapyr and bifenazate. Both buprofezin and acetamiprid provided no control of twospotted spider mite nymphs with percent mortality values less than or equal to 6 percent and greater than or equal to 32 live twospotted spider mite nymphs per plant, which was not surprising because neither pesticide is registered for twospotted spider mite.

Many studies evaluating pesticide mixtures have been conducted under laboratory conditions. However, there are relatively very few studies that have evaluated pesticide mixtures under greenhouse conditions. We assessed pesticide mixtures in a greenhouse environment and detected ➧

Twospotted Spider Mite Results				
	7 Days After Treatment		14 Days After Treatment	
Treatment*	Total TSSMN	PMORT TSSMN	Total TSSMN	PMORT TSSMN
BU	186	0f**	188	2bc**
AC	157	8ef	184	6b
CH	157	94ab	152	100a
BI	179	48cd	94	100a
BU + CH	170	94ab	160	100a
BU + BI	180	36de	108	100a
AC + CH	214	90b	149	100a
AC + BI	202	64c	128	100a
AC + BU + CH	156	100a	144	100a
AC + BU + BI	197	42cd	128	100a
AC + CH + BI	150	100a	141	100a
Untreated check	212	0f	316	0c
Water control	220	0f	402	0c

** Treatment designations: BU=buprofezin, AC=acetamiprid, CH=chlorfenapyr and BI=bifenazate.*
*** Means within a column followed by a common letter are not significantly different. (P=0.05) as determined by Tukey's standardized range (HSD) test.*

Figure 4. Total number of twospotted spider mite nymphs (TSSMN) per treatment and percent nymphal mortality (PMORT TSSMN) for four pesticides and pesticide mixtures seven and 14 days after treatment; n=5.

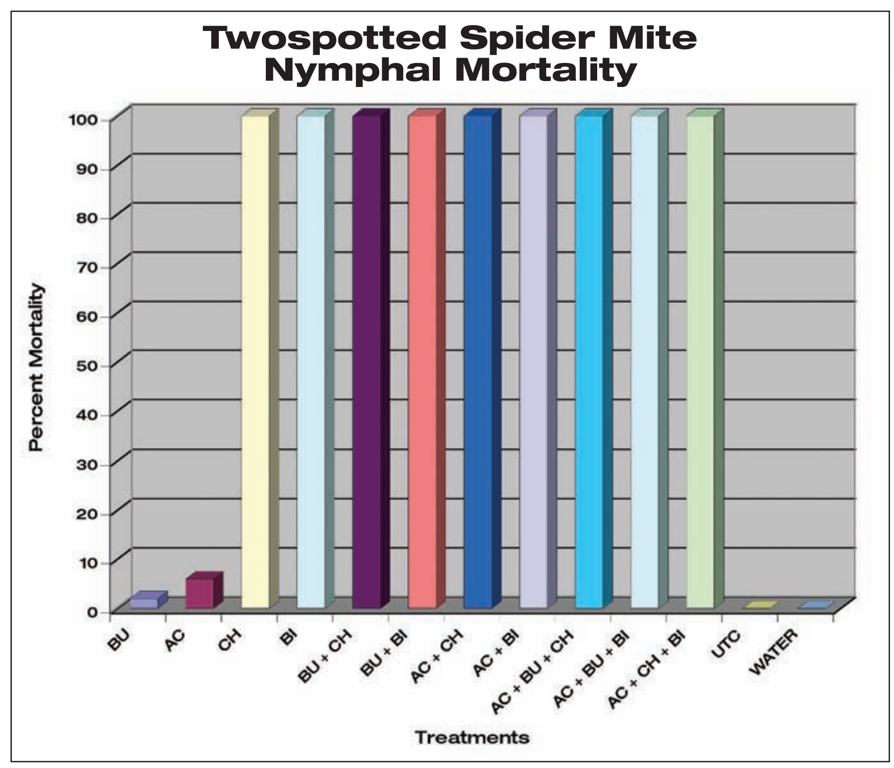

Figure 5. Percent nymphal mortality of twospotted spider mite (Tetranychus urticae) *for the four pesticides and pesticide mixtures 14 days after treatment.*

minimal indications of antagonism occurring among the 2- and 3-way mixtures. This study has demonstrated that, in general, greenhouse producers may tank mix the evaluated pesticides without compromising control of either the silverleaf whitefly or the twospotted spider mite. GPN

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