Entomology

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Monitoring and Managing Whitefly Resistance to Neonicotinoid Insecticides in Floriculture Crops

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Index Words: Bemisia, insecticide resistance, resistance management, imidacloprid

Significance to the Industry: The observed patterns of resistance to neonicotinoid insecticides in whitefly populations affecting greenhouse crops in Europe, the recent collection of highly resistant *Bemisia tabaci* populations in Mexico and the United States, and the relatively recent introduction of several neonicotinoid insecticides for the floriculture industry indicate the need for resistance avoidance and mitigation strategies. Resistance selection and subsequent loss of neonicotinoid efficacy would result in an estimated cost increase of $1.1 million dollars per year in Texas poinsettias alone. Any perceived dispersal of resistant populations into food crops may cause severe public image problems to the industry.

Nature of Work: Resistance to neonicotinoid insecticides in *Bemisia tabaci* populations in the United States has been observed after successive selection in the laboratory (3) but so far, field resistance has not been reported (2, 6). However, changes in tolerance levels have been detected from populations in cotton and melons in Arizona and tomatoes in Florida (1, 5). The lack of field resistance in these areas may reflect grower implementation of insecticide resistance management guideless developed from resistance monitoring programs. These programs are considered major components of neonicotinoid insecticide resistance management efforts (2). The long term objective of our work is to develop an insecticide resistance monitoring and management program for floricultural crops. The objectives of the present study were to initiate the process by focusing on a high risk pest- host plant -insecticide complex, *Bemisia,* poinsettias and imidacloprid. Our specific objectives were to obtain baseline susceptibility data for imidacloprid in *Bemisia* whiteflies attacking floricultural crops in Texas; to implement a neonicotinoid resistance monitoring program; and to distribute resistance management information for floricultural crops using existing extension education programs. Here we report results of preliminary bioassays to determine baseline susceptibility to imidacloprid in a *B. tabaci* biotype B laboratory colony and resistance ratios for two greenhouse populations in Texas.

A *Bemisia tabaci* biotype B colony maintained in the laboratory since 2000 without exposure to insecticides was used as a source of susceptible insects. Solutions of 0 to 100 ppm imidacloprid (Marathon® II) were used to drench cotton seedlings growing in soil-less media in 6- inch pots (soil systemic bioassay). Seedlings with two true-leaves were cut at the base of the stem at 24, 48 and 72 hours after drench to determine the effect of uptake time on lethal concentration (LC) estimates. Single treated seedlings were provided with moisture by placing stems into micro-centrifuge tubes filled with distilled water. Seedlings were then placed inside 150 mm (diameter) × 25 mm (depth) Petri dishes. Twenty adults were introduced into each Petri dish and the dishes were sealed with Parafilm® to avoid whitefly escape. Each concentration was tested 4 to 8 times (one dish = one replicate) at each of the three up-take time treatments. Whitefly mortality was assessed 24 hours after exposure to treated seedlings. Probit analyses were conducted to determine LC_{50} and LC_{90} values. Using the above methods, two suspect greenhouse populations from commercial operations in north and southeast Texas were assayed for susceptibility to imidacloprid concentrations and resistance ratios were calculated using the susceptible laboratory colony as the ratio divisor (4).

Results and Discussion: As expected, whitefly mortality increased linearly with imidacloprid concentration. LC_{50} values were 25.4, 1.2 and 0.2 ppm for bioassays with uptake times of 24, 48 and 72 hours, respectively. Similarly, LC_{90} values were 69.6, 26.8 and 5.4 ppm for the same uptake time periods (Figure 1). These values are within the range of label recommendations (28.3 ppm), lower than those previously reported from soil systemic bioassays but similar in magnitude to those reported from leaf-disk bioassays (3). Based on the slope of regression lines and the variability around LC_{50} estimates, an uptake time of 48 hours was used in subsequent bioassays. Resistance ratios of the susceptible and two commercial greenhouse populations appear in Table 1. High resistance ratios (RR > 5) indicate resistance to imidacloprid; however large variability in experimental data in test using TXGH2 population yielded very high and non-significant chi-square values (Table 1). The occurrence of resistance in these populations is not surprising considering neonicotinoid insecticide use patterns. Resistance management recommendations were provided to these growers. Populations will be tested again in 2007 to determine changes in susceptibility to imidacloprid and impact of resistance management practices.
This work was partially funded by USDA-ARS Floriculture and Nursery Research Initiative (agreement numbers: 58-6204-0-0106 and 58-6204-5-0033) and the Fred C. Gloeckner Foundation Inc.

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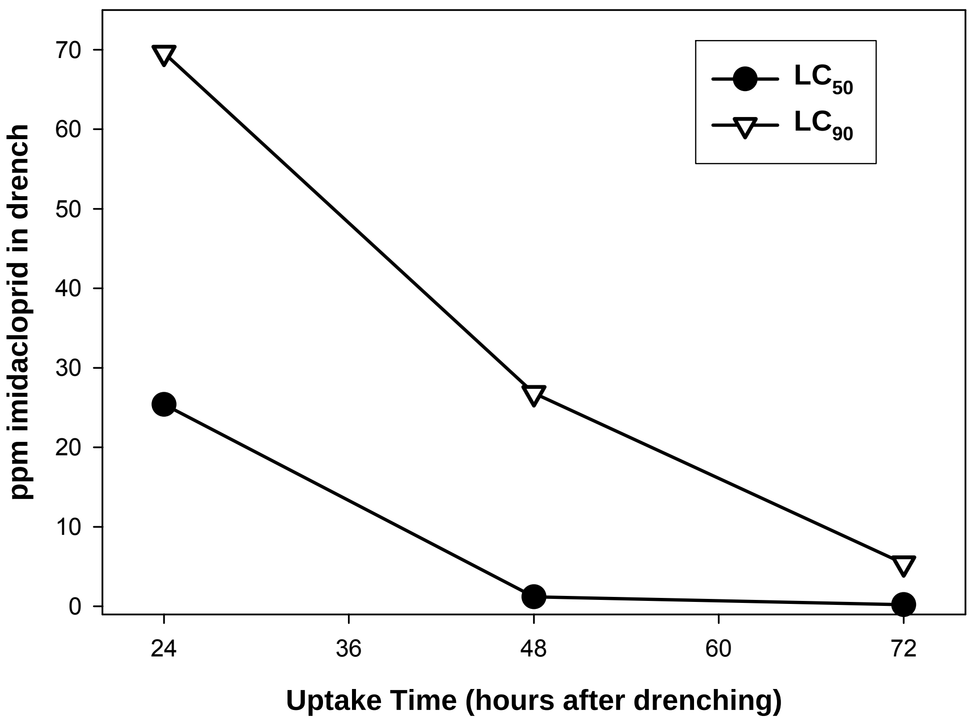

Figure 1. Lethal concentration values of imidacloprid at different uptake times in soil systemic bioassay

Table 1. Probit analyses of two *Bemisia tabaci* populations from commercial greenhouses in Texas and susceptible laboratory colony.

Whitefly Population	n[a]	Slope ± SE	LC_{50}[b] (95% CL)	LC_{90}[b] (95% CL)	RR[c] LC_{50} (95% CI)	RR[c] LC_{90} (95% CI)	χ^2 (df)
TAMU Lab Colony[d]	870	0.94 ± 0.85	1.19 (0.55–2.07)	26.79 (15.73–54.96)	1	1	5.54 (5)
TXGH1	767	1.00 ± 0.97	81.66 (48.73–125.54)	1,530.72 (950.22–2,817.56)	**68.39** (35.21–132.85)	**57.15** (28.24–115.64)	2.12 (4)
TXGH2	927	0.74 ± 0.51	190.89[e] (31.82–866.27)	10,051[e] (1767.9–1.9 X 10^6)	**159.89** (90.96–281.06)	**374.96** (180.18–780.28)	82.2 (5)

[a] Number of insects tested.
[b] Lethal concentration expressed in parts per million of insecticide with 95% confidence limits.
[c] Resistance ratio, RR, with 95% confidence intervals. **RR** indicates a significant difference from the susceptible TAMU laboratory colony.
[d] Bioassay of TAMU susceptible laboratory colony.
[e] 90% confidence limits. Bold RR is significantly different than susceptible TAMU laboratory colony

Impact of fertilization on biological and chemical control of two-spotted spider mites on greenhouse roses

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Index Words: *Tetranychus urticae, Phytoseiulus persimilis*, *Rosa hybrida*, fertilizer, miticide, bifenazate, biological control, cut flower

Significance to Industry: Over fertilization of floriculture crops can contribute to higher pest control costs because populations of two-spotted spider mite (TSSM), *Tetranychus urticae* Koch, respond positively to high nutrient levels in the crop. Reduction of fertilization could be a useful tactic in an integrated pest management program if TSSM populations could be reduced without losses in crop yield and productivity. In this study, we compared cut roses grown under fertilizer regimes representing 10% or 100% of the commercially recommended rate (150 ppm N). In each regime, we measured the abundance and distribution of TSSM, the abilities to control of TSSM with either releases of a predatory mite (*Phytoseiulus persimilis* Athias-Henriot) or applications of Floramite® (bifenazate), and crop yield. Roses fertilized with 10% of the recommended rate and treated with predatory mites or miticide had, on average, 60–70% fewer spider mites and 70–80% fewer spider mite eggs than plants fertilized with 100% of the recommended rate and treated with similar control methods. Unprotected plants fertilized with the lower rate had, on average, around 40% fewer spider mites and spider mite eggs than those treated with the recommended level. Because plants fertilized at the recommended rate produced on average 2.5 times as many harvestable cut flowers as those fertilized at the lower rate, additional work will need to be completed to determine if less drastic reductions in fertilizer could improve TSSM management without a significant reduction in crop yield and quality.

Nature of Work: Two-spotted spider mites (TSSM) are a serious pest of roses and a wide range of other ornamental crops worldwide (1, 2). Intensive miticide use for TSSM is often necessary to meet consumer demands for floricultural crops. Widespread use of miticides has resulted in resistance to a number of miticides making control of TSSM more difficult (3). As an alternative to chemical control, predatory mites of the family Phytoseiidae, particularly *Phytoseiulus persimilis* Athias-Henriot, are commercially available for biological control of spider mites (4).

Reduction of fertilization could be a useful tactic in an integrated pest management program, and thus reducing dependence on chemical or biological control, if altered fertilization regimes reduced TSSM populations with little loss in crop yield and productivity. Lowering fertilization to 75 ppm N, 50% of the recommended level (150 ppm N) for U.S. commercial production of cut roses (*Rosa hybrida* L.) reduces numbers of TSSM eggs on plants by 26.8% with no loss in productivity or quality (5). The objectives of this study are to compare yield of cut roses grown under fertilizer regimes (10% or 100% of the commercially recommended rate), to measure the abundance and distribution of TSSM, and to evaluate control of TSSM with either releases of a predatory mite (*Phytoseiulus persimilis*) or applications of Floramite® (bifenazate).

Roses were grown from bare-root stock (cv. 'Tropicana' grafted onto 'Dr. Huey' rootstock) planted in 14-L, plastic nursery-containers with soil less mix (Sunshine Mix no.1; Sun Gro Horticulture Canada, Bellevue, WA), pine bark, and sand (3:1:1 ratio). Roses were cultured as a cut flower crop in a greenhouse using conventional cultivation practices (6). Sixty days before the experiment, one set of plants were fertilized with the low fertilization rate (10 %) and the second set with the recommended rate (100 %) with a water-soluble, complete fertilizer (Peters Excel 15-5-15 Cal-Mag, Scotts, Marysville, OH). Reverse-osmosis-filtered tap water (RO water) was used to make the fertilizer solutions and water the plants.

We tested the two fertilization levels with three types of pest infestation and control methods for a total of six different treatments. The pest infestation and control methods were: inoculation with TSSM followed by no control measures, inoculation with TSSM followed by releases of *P. persimilus*, inoculation with TSSM followed by a miticide application. Thirty-six rose plants were used and each plant was a replicate. Plants were placed on six greenhouse benches in a randomized design with one replicate per treatment per bench, totalling six replicates per treatment.

Six adult female TSSM were released onto each plant. Two and four weeks after infesting the plants with TSSM, we obtained *P. persimilus* from Koppert Biological Systems (Romulus, Michigan) and released *P. persimilus* onto each plant assigned the predatory mite treatment. Following recommendations by Koppert, we released 36 adult predatory mites per plant during the second and fourth weeks. Three weeks after TSSM infestation, we sprayed each plant assigned the miticide treatment with a single application of Floramite® at the recommended rate (1.134 g /gallon). We used RO water to make the miticide solution and sprayed each plant until runoff.

At the beginning of the sixth week, we visually inspected each plant and counted the total number of leaves in the canopy and the number infested with TSSM. We then randomly removed 10% of the infested leaves and used a dissecting microscope to count the total number of all TSSM stages found on these leaves. We harvested flowering shoots when the flowers had fully opened, starting about six weeks after TSSM inoculation. We used two-way ANOVA, with fertilization rate and control method as main effects, to compare counts of leaves, TSSM stages, and harvested flowers.

Results and Discussion: Rose plants fertilized with the recommended rate produced nearly 50% more leaves (154.4 ± 9.1 leaves, n = 18) than plants fertilized with the lower rate (105.6 + 7.6 leaves, n = 18) (two-way ANOVA: $F_{1, 30} = 15.96$; $P < 0.001$). However, the proportion of leaves infested by TSSM did not differ significantly with fertilization rate (two-way ANOVA: $F_{1, 30} = 0.07$; $P = 0.796$) or control method (two-way ANOVA: $F_{2, 30} = 0.54$; $P = 0.587$) and was slightly more than half of the canopies (0.57 ± 0.06, n = 36). Plants fertilized with the lower rate and treated with predatory mites or miticide had, on average, 60–70% less spider mites (adults & nymphs) (two-way ANOVA: $F_{1, 30} = 4.49$; $P = 0.042$) and 70–80% fewer spider mite eggs (two-way ANOVA: $F_{1, 30} = 5.62$; $P = 0.024$) than plants fertilized with the recommended rate and treated with similar control methods (Figures 1 & 2). Similarly, unprotected plants fertilized with the lower rate had, on average, around 40% fewer spider mites and spider mite eggs than those fertilized with the recommended rate (Figures 1 & 2).

More flowering shoots were harvested from plants fertilized with the recommended rate (3.2 ± 0.4 flowers per plant, n = 18) than plants fertilized with the lower rate (1.3 ± 0.3 flowers per plant, n = 18). Lowering fertilization to 50% of the recommended level can reduce numbers of TSSM eggs on cut roses by 26.8% with no loss in either cut flower productivity or quality (5). Future studies are needed to evaluate the feasibility of significantly reducing spider mite populations and producing high yields of marketable cut roses with fertilization between 10–50% of the recommended rate.

This research was supported by the USDA–ARS Floriculture and Nursery Research Initiative (awarded to K.M.H.), the Texas Department of Agriculture - Israel Binational Agriculture Research and Development Fund (awarded to A. Chow and K.M.H.), the K.M. Heinz Ornamental and Nursery Crop Endowment, and by Ran-Pro Farms, Inc. for their donation of bare-root rose plants.

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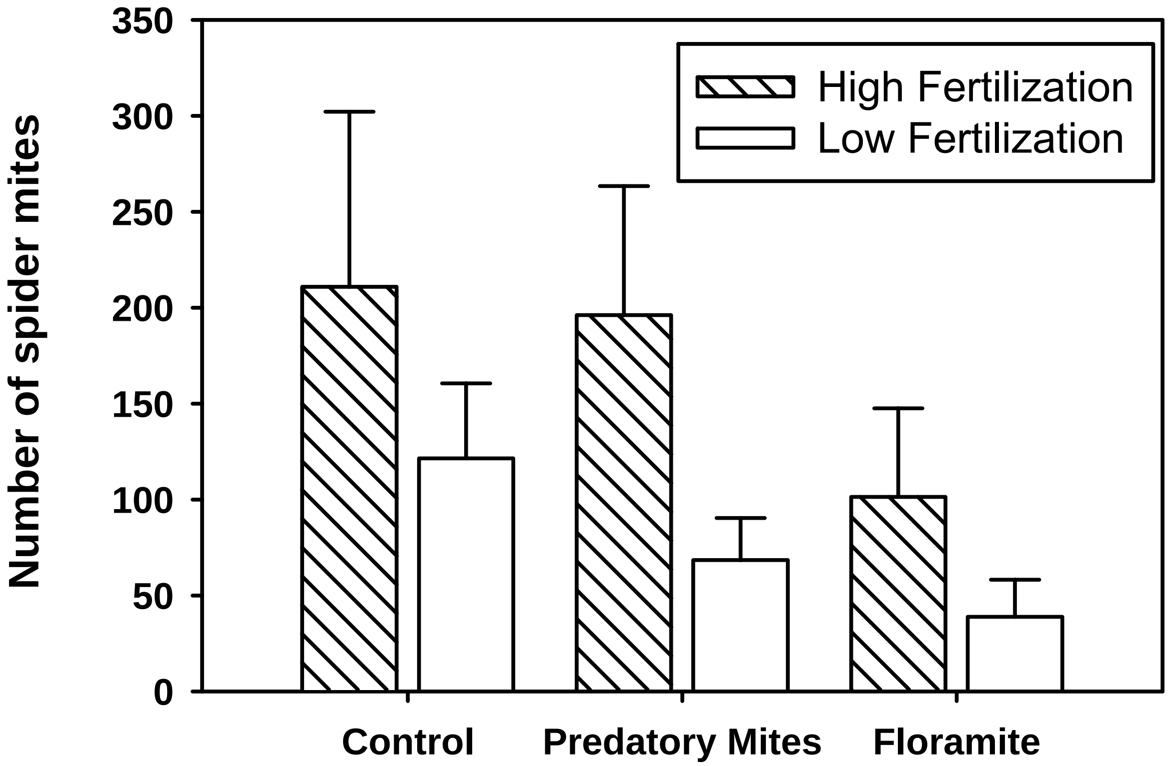

Figure 1. Mean numbers of two-spotted spider mites (adults and nymphs) (+ SE) counted on 10 % of all infested leaves from plants fertilized at 10% or 100% of the recommended fertilization rate and treated with releases of a predatory mite "*Phytoseiulus persimilis*" (n = 6), applications of Floramite ® (n = 6), or no control methods (n = 6).

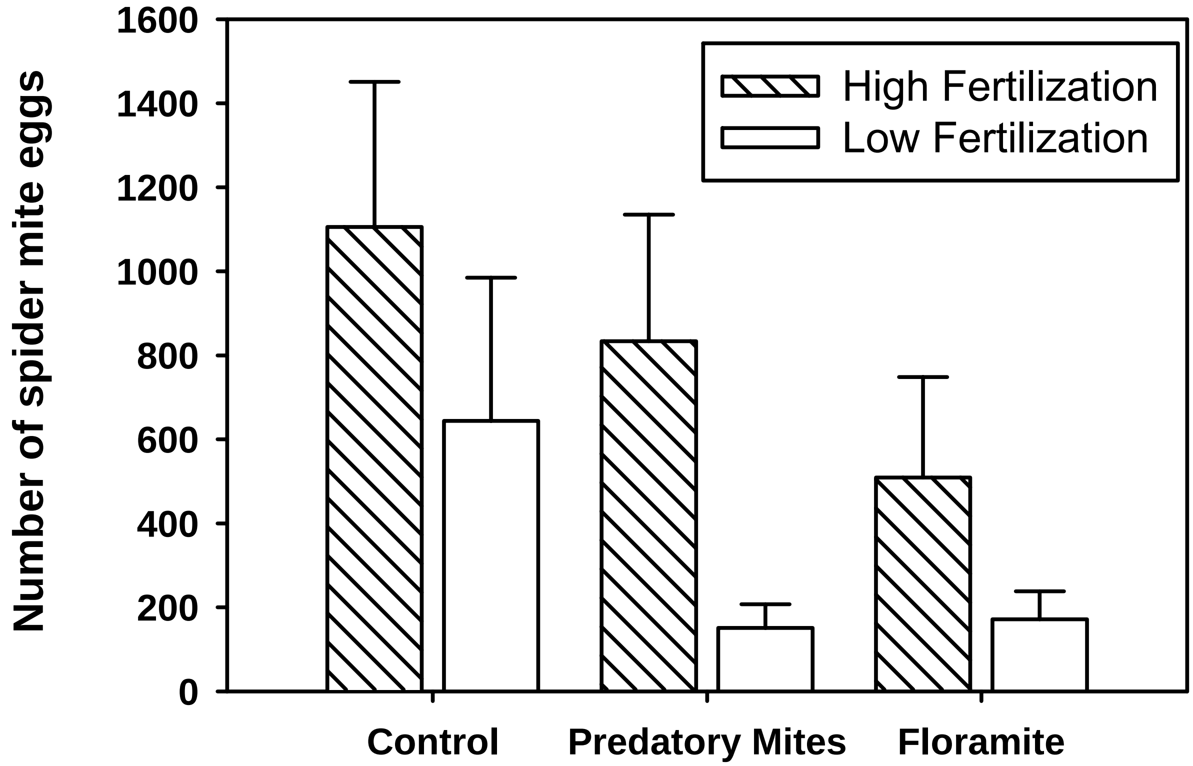

Figure 2. Mean numbers of two-spotted spider mite eggs (+ SE) counted on 10 % of all infested leaves from plants fertilized at 10% or 100% of the recommended fertilization rate and treated with releases of a predatory mite “*Phytoseiulus persimilis*” (n = 6), applications of Floramite ® (n = 6), or no control methods (n = 6).

Two Predators Are Better than One! Combining *Amblyseius swirskii* and *Orius insidiosus* for Control of Thrips on Greenhouse Roses

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Index Words: Biological control, Inundative releases, *Amblyseius swirskii*, *Frankliniella occidentalis*, *Orius insidiosus*, Cut roses

Significance to Industry: Despite the widespread use of insecticides, western flower thrips (WFT), *Frankliniella occidentalis* (Pergande), are still difficult pests to control on floricultural crops. Western flower thrips are often able to escape the effects of insecticides due to their ability to escape contact with them by hiding within plant parts and to the widespread occurrence of resistance. As an alternative to chemical control, we evaluated the use of the predatory mite, *Amblyseius swirskii* (Anthias-Henriot), alone and together with the predatory bug, *Orius insidiosus* (Say), for suppressing WFT on roses. In greenhouse trials simulating commercial production of cut roses, we compared control of WFT with releases of both *A. swirskii* and *O. insidiosus* or only *A. swirskii*. We found that roses with or without predators produced similar numbers of harvestable flowers, but roses without predators had up to eight times the number of thrips as roses with predators. Releases of both predators yielded plants with, on average, 39% fewer thrips than plants receiving only releases of *A. swirskii*. Given these promising management results, we recommend further studies to determine the most cost-effective use of both predator species for thrips control.

Nature of Work: A growing trend among biological control programs is to use two or more species of natural enemies to suppress populations of insect pests. Biological control programs for ornamental crops often use combinations of predators, parasitoids, or pathogens against thrips (1), whiteflies (2), aphids (3), and agromyzid leafminers (4). For practitioners of biological control, an important question is: will multiple predators suppress populations of pests more effectively than a single predator?

Two groups of predators, predatory bugs of the genus *Orius* and predatory mites of the genus *Amblyseius*, are commercially available in the US for biological control of western flower thrips (WFT), *Frankliniella occidentalis* (Pergande). Chemical control for WFT on cut roses and other ornamental crops can be difficult because this pest has developed resistance to many insecticides and also tends to hide within flowers, buds, and apical meristems (5). A new predatory mite, *Amblyseius swirskii* (Anthias-Henriot), has been highly recommended as a control agent for WFT (6). *Amblyseius swirskii* can reach confined habitats preferred by WFT but kill primarily first-instar larvae. *Orius insidiosus* (Say) has also been used to control thrips on greenhouse-grown crops, particularly sweet pepper (7). This anthocorid bug preys on both larvae and adult thrips and can suppress high WFT densities but has limited ability to attack thrips within confined plant parts. We were interested in whether use of both agents may provide both effective and cost efficient control of WFT through complimentary predation.

Our objective was to determine if suppression of WFT on greenhouse cut roses by inundative releases of *A. swirskii* could be enhanced by concurrent releases of *O. insidiosus*. For our greenhouse study, we established our roses from bare-root rose stock (*Rosa hybrida* L. cv. 'Tropicana' grafted onto 'Dr. Huey' rootstock) individually planted in 14-L, plastic nursery-containers with soilless mix (Sunshine Mix no.1, Sun Gro Horticulture Canada, Bellevue, WA), pine bark, and sand (3:1:1 ratio). Plants were cultivated as a cut flower crop following conventional guidelines (8) in greenhouses on the Texas A&M University, College Station campus for 12 months before being used for our study. We compared control of WFT under conditions simulating greenhouse production in Texas by exposing roses to only WFT, WFT and predatory mites, or WFT with both predatory bugs and predatory mites. The number of replications was three per treatment and the three treatments were equally distributed within a randomised block design, using position within the greenhouse as the blocking factor. All natural enemies were obtained from Koppert Biological Systems (Romulus, Michigan).

Each replicate consisted of twelve potted plants spaced 5 cm apart and arranged in a 6-by-2 grid on a greenhouse bench enclosed by a PVC frame (120-inch long x 50-inch wide x 48-inch high) sheathed with thrips-proof screen. In each cage we released 32 adult females and 8 adult males of WFT twice each week over five consecutive weeks and then once each week over three consecutive weeks (total = 520 thrips over 13 releases per replicate). During the same week of the first thrips release (week 1), we hung a single sachet (slow release bag, Swirski-Mite Plus ™) of *A. swirskii* near the center of each potted plant in all replicates assigned predatory mites. Four weeks later, following release recommendations by Koppert, we replaced all the old sachets with new ones (week 5). To determine the release rate of *A. swirskii* during the study, we used non-toxic putty (Plast-i-clay ®, American Art Clay Company, Indianapolis, IN) to fix a single 'monitor' sachet onto the center of a sticky card (5-inch L x 3-inch W, Stiky Strips™, Olson Products, Medina, OH) and placed one card within the crop of each replicate assigned predatory mites. Each week, we counted all predatory mites captured on the sticky surface of each card and replaced the old cards with new ones. Beginning one week after the first thrips releases (week 2), we released eight adult female and eight adult male predatory bugs each week over six consecutive weeks in all replicates assigned both predatory mites and predatory bugs (total = 96 bugs over six releases per replicate).

The experiment was conducted in a greenhouse on the Texas A&M University, College Station campus from May to July 2006. Two weeks after the first thrips were released (week 3), we harvested all shoots with flowers that opened recently (before pollen release). Flowers were harvested three times each week during the third to tenth weeks of the crop. Flowers were cut from the harvested shoots and placed in individual plastic containers. The vegetative part of each harvested shoot was placed in a separate plastic container. Using a standard protocol developed by our research group (9), we extracted WFT from the flowers and counted all WFT stages. We analyzed weekly counts of harvested flowers, WFT from flowers, and *A. swirskii* captured on sticky cards with one-way repeated-measures ANOVA using treatment as the main effect.

Results and Discussion: In our greenhouse study, we found significant differences between WFT counts from flowers harvested from plants exposed to only WFT or WFT and predators (one-way repeated measures ANOVA: $F_{2, 6}$ = 22.71; P = 0.002) (Figure 1). Thrips counts were similar for all treatments during the third week, but were up to eight times higher for plants without predators than for plants with predators during the fourth to tenth weeks. Flowers from plants without predators always had the most WFT, but thrips counts for flowers from plants protected by only *A. swirskii* were, on average, 39% higher than counts for flowers from plants with both predators. Numbers of open flowers were similar for all treatments (one-way repeated measures ANOVA: $F_{2, 6}$ = 0.73; P = 0.522) and started at 11.44 ± 0.77 (n = 9; ± SE) in the first week, increased to 19.67 ± 1.19 (n = 9; ± SE) by the third week, and gradually declined to 15.00 ± 1.64 (n = 9; ± SE) by the tenth week. The numbers of *A. swirskii* released from the monitor sachets was similar for both predator treatments (one-way repeated measures ANOVA: $F_{1, 4}$ = 1.49; P = 0.290) and peaked during the second or third weeks of use (week 1–4 = first set of sachets, week 5–8 = second set of sachets) but quickly declined by the fourth week (Figure 2). We estimated that around 500–700 predatory mites were released onto each rose plant during the first eight weeks of the study.

In a previous study, *O. insidiosus* showed preference for *Amblyseius degenerans* over adult WFT and control of WFT was reduced by concurrent releases of both predator species (10). From this study, we concluded that concurrent releases of both *A. swirskii* and *O. insidiosus* enhanced thrips control because roses with both predators had lower numbers of thrips than roses protected by only *A. swirskii*. Given these promising management results and the reasonable costs of *A. swirskii*, $256.00 US per 500 sachets, and *O. insidiosus*, $48.00 US per 500 bugs, we recommend further studies to determine the most cost-effective use of both predator species for thrips control.

Acknowledgements: This research was supported by the USDA-ARS Floriculture and Nursery Research Initiative (awarded to K.M.H.), the Texas Department of Agriculture - Israel Binational Agriculture Research and Development Fund (awarded to A. Chow and K.M.H.), the K.M. Heinz

Ornamental and Nursery Crop Endowment, and by Ran-Pro Farms, Inc. for their donation of bare-root rose plants. We are also grateful to Koppert Biological Systems Inc. for providing natural enemies at cost and Pete Krauter for his technical support.

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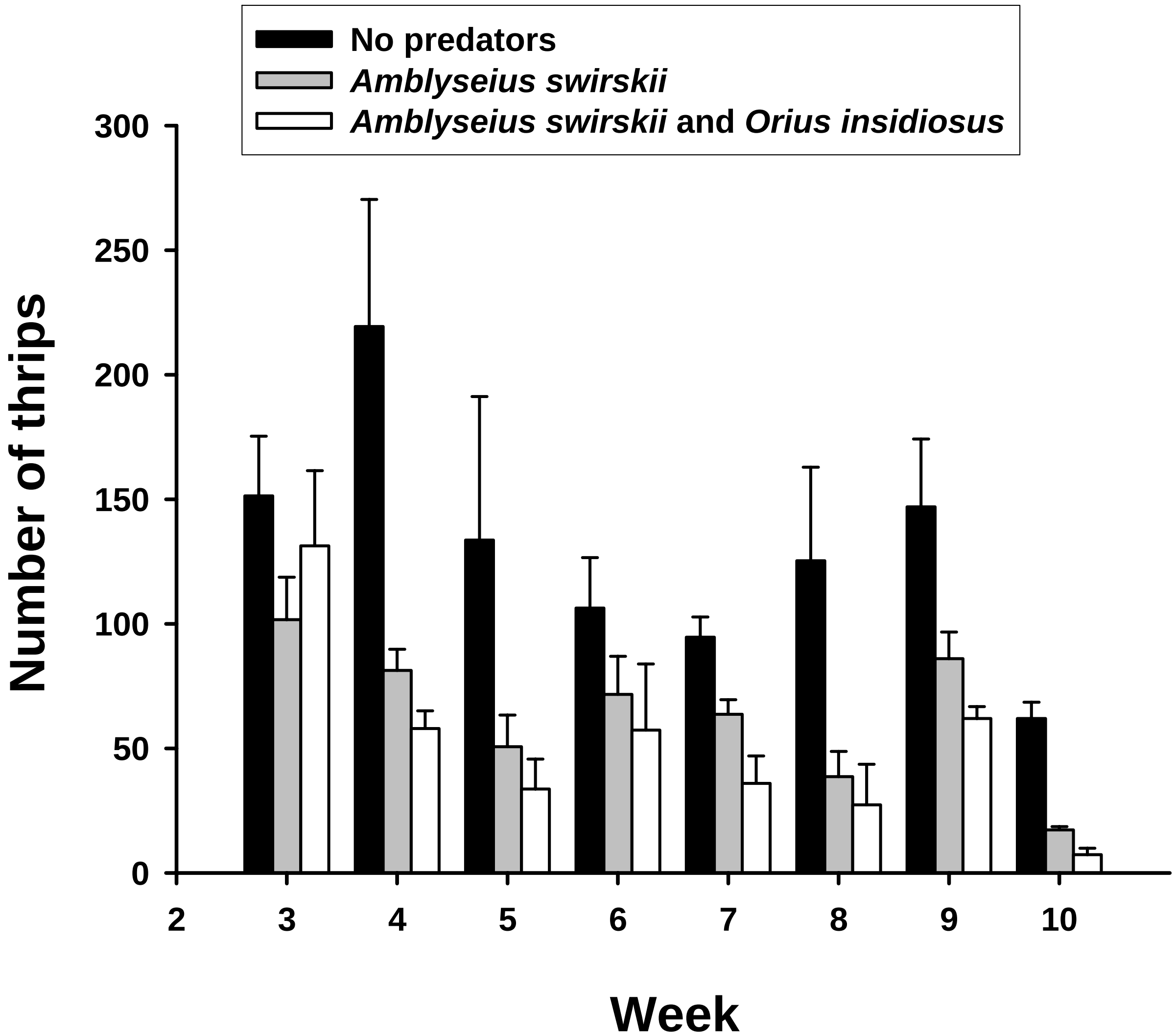

Figure 1. Weekly counts of adult *Frankliniella occidentalis* (WFT) (mean + SE) in cut roses exposed to 'no predators' (= ■) or *Amblyseius swirskii* (= ■) or both *Orius insidiosus* and *A. swirskii* (= □), n = 3 per treatment, 12 plants per replicate. Releases of WFT began in the first week and finished in the eighth week. Releases of *O. insidiosus* began in the second week and finished in the seventh week. Sachets of *A. swirskii* were introduced in the first week and fifth week.

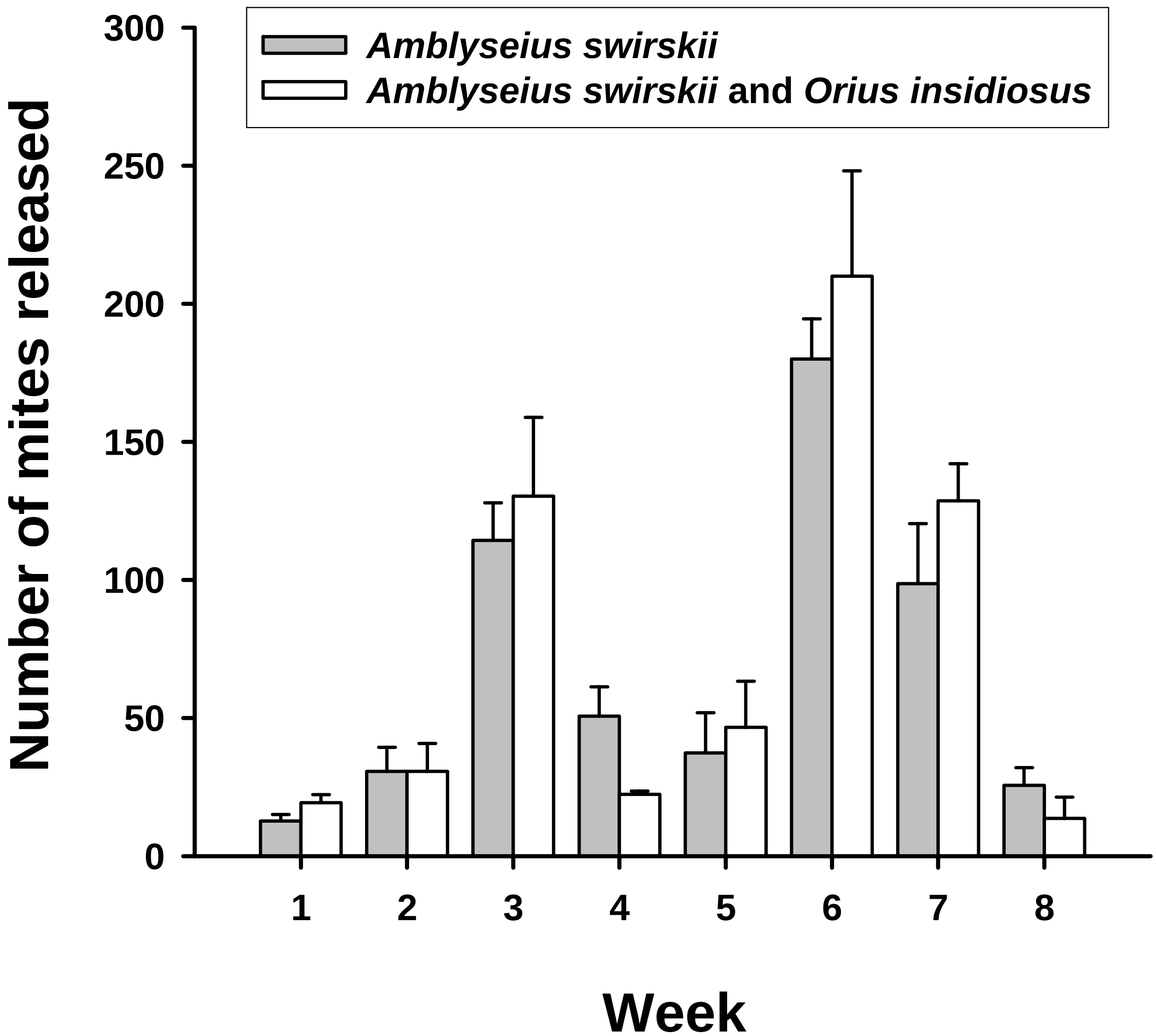

Figure 2. Weekly counts of *Amblyseius swirskii* (mean ± SE) released from two consecutive sets of monitors sachets (set 1 = weeks 1-4; set 2 = weeks 5-8) placed among cut roses exposed to *Frankliniella occidentalis* and *A. swirskii* (= ☐) or *F. occidentalis* and *Orius insidiosus* and *A. swirskii* (= ■), n = 3 per treatment.

Entomological Research Priorities for Nursery and Landscape Ornamentals

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Index Words: Granulate ambrosia beetle, Japanese beetle, two-lined spittlebug, citrus whitefly, aphid, whitefly, azalea lace bug, scale insect, soft scale, armored scale, mealybug, flatheaded borer, roundheaded borer, obscure scale, gouty oak gall, horned oak gall, broad mite, twospotted spider mite, southern pine beetle, bark beetles, magnolia borer, root collar borer, tea scale, white peach scale, tuliptree scale, Florida wax scale, tobacco aphid, periodical cicada, psyllid, strawberry rootworm, whitefringed beetle, hibiscus bud weevil, European hornet, western flower thrips, fungus gnat, leafminer, leaf tier, leafroller, imidacloprid, thiamethoxam, neonicotinoid, acetamiprid, dinotefuran, pyriproxyfen, mode of action.

Significance to Industry: While effective control options exist for most insect and mite pests of landscape ornamental plants, there are some pests that are extremely difficult to control or lack any efficacious control options. Identifying these pests and prioritizing the need for collaborative research efforts is an important first step. Plans can be made when entomologists in the Southern U.S. meet for their annual Southeast Ornamental Entomology Workshop. Identified pest problems can also be presented to the IR-4 program for help in coordinating research efforts.

Nature of Work: A survey was presented to entomologists at a Southeast Ornamental Entomology Workshop on May 17 and 18, 2007 at the University of Georgia in Athens. Those attending were asked to list insect and mite pests of plants that were the most difficult to control and for which there is no effective control. The respondents were asked to prioritize them according to their research need with one being the highest priority and six being the least. This was done for insect and mite pests of plants grown in the commercial nursery, commercial greenhouse, and in the landscape. Five respondents prioritized insect and mite pests of landscapes, six prioritized commercial nursery pests, and five prioritized commercial greenhouse pests.

Results and Discussion: In 1994, one of these same entomologists and six others wrote a paper for the SNA Research Conference entitled an Update on Management of the Top Seven Landscape Pest Groups (1). The seven groups of insect or mite pests listed were mites, scale insects, aphids, borers, caterpillars, lace bugs, and a miscellaneous category that included Japanese beetle, *Popillia japonica* Newman, two-lined spittlebug, *Prosapia bicincta* (Say), and citrus whitefly, *Dialeurodes citri* (Ashmead).

In the years since, many new insecticides and miticides have become available that have had a major effect on the improved management of many of these and other plant pests. The advent of the systemic imidacloprid (Merit®, Bayer Environmental Science, Research Triangle Park, NC; Marathon®, OHP, Mainland, PA), thiamethoxam (Flagship™, Syngenta Crop Protection, Greensboro, NC) and the other neonicotinoid class insecticides (Group 4A Insecticide Mode of Action) (2) that followed has seen the level of control increase dramatically for aphids, whiteflies, lace bugs, scale insects, Japanese beetles, flatheaded borers, and roundheaded borers. In the last few years, neonicotinoid insecticides containing acetamiprid (TriStar™, Cleary Chemical, Dayton, NJ) and dinotefuran (Safari™, Valent U.S.A., Walnut Creek, CA) in addition to the earlier developed pyridine insect growth regulator, pyriproxyfen (Distance®, Valent U.S.A.) in the Group 7 Insecticide Mode of Action grouping (2), have given us effective tools to manage most armored scale.

There have been many new miticides developed since 1994. The ability for mites to increase to high numbers in a relatively short amount of time still makes mites an often difficult to control pest. Not all pest mites are spider mites and examples of other types of pest mites include cyclamen mite, *Phytonemus pallidus* (Banks); broad mite, *Polyphagotarsonemus latus* (Banks); eriophyid mites (Eriophyidae); and flat mites (Tenuipalpidae). Also, most miticides are more effective on some types of mites than others.

In the landscape for the most difficult to control pests, mites had a rank of 2 and 3 while spruce spider mite, *Oligonychus ununguis* (Jacobi), had a rank of 5 for the most difficult to control pests. One respondent listed mites as a pest with no effective control available in the landscape with a rank of 4.

In the commercial nursery for the most difficult to control pests, mites had a rank of 4 as a research priority for two respondents while southern red mite, *Oligonychus ilicis* (McGregor), had rank of 5. For no effective control, mites other than spider mites had a rank of 2.

In the commercial greenhouse for the most difficult to control pests, broad mite had a rank of 1 and a rank of 2. Mites had a rank of 3 and spider mite had a rank of 5 while twospotted spider mites, *Tetranychus urticae* Koch, had a rank of 5. Broad mites had a rank of 2 for having no effective control in the commercial greenhouse. Thus, mites remain a pest of concern, especially in the commercial greenhouse.

Borers were one of the top seven pest groups in 1994 (1) and are a top research priority in this study. For most difficult to control, the granulate ambrosia beetle (formerly called the Asian ambrosia beetle), *Xylosandrus crassiusculus* Motschulsky, had a rank of 1 from three respondents for the commercial nursery. It had a rank of 1 and a rank of 2 from two respondents for the landscape. For no effective control, the granulate ambrosia beetle had a rank of 1.

Borers other than the granulate ambrosia beetle were also still a research priority in 2007. In the commercial nursery for the most difficult to control arthropod pests, borers had a rank of 1, beetle borers had a rank of 2, southern pine beetles, *Dendroctonus frontalis* Zimmermann, had a rank of 2 and flatheaded borers had a rank of 3. In the commercial nursery for no effective control, magnolia borer, *Euzophera magnolialis* Capps, had a rank of 1. Other beetle borers had a rank of 3.

In the landscape for most difficult to control pests, the southern pine beetle and other bark beetles had a rank of 2 and bark beetles had a rank of 3. Other beetle borers had a rank of 5. Clearwing borers and the root collar borer, *Euzophera ostricolorella* Hulst, are Lepidoptera borers and they both had a rank of 4. For no effective control, pine bark beetles had a rank of 1.

Scale insects were an important research priority in the previous study (1) and remain so in the present study. Mealybugs are also considered a type of scale insect. For the most difficult to control in the commercial nursery, tea scale (*Fiorinia theae* Green), an armored scale, had a rank of 1. Another armored scale, cycad aulacaspis scale *Aulacaspis yasumatsui* Takgi) had a rank of 2; armored scale, especially white peach scale, *Pseudaulacaspis pentagona* (Targioni Tozzetti), had a rank of 3; white peach scale had a rank of 5; and mealybugs had a rank of 3. Florida wax scale, *Ceroplastes floridensis* Comstock, had a rank of 3. For no effective control, both armored scale and obscure scale, *Melanaspis obscura* (Comstock), a type of armored scale, had a rank of 1.

In the commercial greenhouse for most difficult to control, mealybugs had a rank of 2 and a rank of 4. Scale insects had a rank of 3 and a rank of 4. Armored scale had a rank of 4.

In the landscape for most difficult to control, armored scale had a rank of 1 as did mealybugs. Armored scale, especially white peach scale, had a rank of 5. Florida wax scale had a rank of 1 and tuliptree scale, *Toumeyella liriodendri* (Gmelin), a soft scale, had a rank of 1.

Scale insects in the landscape with no effective control included a rank of 1 for armored scale, a rank of 2 for obscure scale, and a rank of 3 for euonymus scale, *Unaspis euonymi* (Comstock), which is an armored scale.

In the commercial nursery for most difficult to control, aphids had a rank of 5. In the commercial greenhouse for most difficult to control, tobacco aphid, *Myzus nicotianae* Blackman, had a rank of 2 and aphids because of a lack of monitoring had a rank of 3. Aphids also had a rank of 6. In the landscape for most difficult to control, hemlock woolly adelgid, *Adelges tsugae* Annand, had a rank of 1.

Caterpillars as defoliators were one of the seven pest groups listed as being important in the landscape (1). In the current study for the most difficult to control landscape pests, leaf tier and leafroller caterpillars only had a rank of 6. Caterpillar defoliators were not listed for both commercial nursery and commercial greenhouse.

Lace bugs were another of the seven pest groups important in the landscape (1). In the landscape for most difficult to control, azalea lace bug, *Stephanitis pyrioides* (Scott), had a rank of 2. Lace bugs were not listed for both commercial nursery and commercial greenhouse.

Japanese beetles, two-lined spittlebug, and citrus whitefly from the category for miscellaneous insects (1) were not listed in the present study. While whiteflies were not listed for most difficult to control landscape pests, they were listed for both commercial nursery and commercial greenhouse. In the commercial nursery, whiteflies had a rank of 4 and rank of 6. In commercial greenhouse, whiteflies had a rank of 2, 3, 5, 5, and 6. The advent of the Q-biotype of *Bemisia tabaci* (Gennadius) may explain much of this interest in increased research for whiteflies.

There are many insect and mite pests that attack ornamental plants. Many of the responses to this survey were for pests that did not belong in any of the seven pest categories used in the 1994 study (1). Additional landscape pests listed for most difficult to control include leaf galls with a rank of 3, thrips with a rank of 4, and lubber grasshoppers, probably referring to the eastern lubber grasshopper, *Romalea guttata* (Houttuyn), with a rank of 4. Those listed for no effective control include gouty oak gall, *Callirhytis quercuspunctata* (Bassett) and horned oak gall, *Callirhytis cornigera* (Osten Sacken) with a rank of 1; grasshoppers with a rank of 2, lubber grasshoppers with a rank of 2; leafminers with a rank of 3; periodical cicadas, *Magicicada* spp. (except when using row cover netting to exclude) with a rank of 3; and psyllids with a rank of 5.

Additional pests listed for the commercial nursery that are most difficult to control include imported fire ants, *Solenopsis* spp. with a rank of 1; both thrips and strawberry rootworm, *Paria fragariae* Wilcox with a rank of 2; galls induced by insects or mites and flatheaded borers with a rank of 3; flea beetles (metallic color ones), whitefringed beetles, *Graphognathus* spp., weevils, especially hibiscus bud weevil, *Anthonomus testaceosquamosus* Linell each with a rank of

4; soil pest larvae, European hornet, *Vespa crabro* Linnaeus both with a rank of 5; and both psyllids and potato leafhopper, *Empoasca fabae* (Harris) with a rank of 6. Those listed as no effective control include gouty oak gall and horned oak gall with a rank of 2, periodical cicada with a rank of 3, and psyllids with a rank of 4.

Additional pests listed for the commercial greenhouse for most difficult to control include thrips, especially western flower thrips, *Frankliniella occidentalis* (Pergande) with a rank of 1 from four respondents; leafminers with a rank of 2; and fungus gnats during plant propagation with a rank of 4. Leafminers with a rank of 1 were listed as having no effective control.

While there have been great strides made in pesticide development and integrated pest control over the past thirteen years, there continues to be a need for entomological research for pests of ornamental plants. This information on pest research priorities will hopefully stimulate collaborative research through IR-4 and other avenues.

Acknowledgements:

Thanks to C. P. Hesselein, C. E. Bográn, D. W. Held, S. Bambara, J. Oliver, and D. K. Pollet from Alabama, Texas, Mississippi, North Carolina, Tennessee, and Louisiana, respectively for their expert opinions on the research priorities for insect and mite pests of ornamental plants in the South.

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Does Capsil improve performance of neonicotinoid insecticides against weeping fig thrips?

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Index Words: *Gynaikothrips uzeli,* adjuvants, organosilicone, surfactants

Significance to the Industry: Adjuvants, surfactants, or spreader-stickers are used extensively by the horticulture industry to reduce surface tension of pesticides in solution, thus increasing coverage and performance of foliar-applied pesticides. Adjuvants made with organosilicones can increase movement of certain pesticides into the leaf thus improving efficacy. Weeping fig thrips are difficult to control with conventional insecticides. The objective of this study was to determine whether adding Capsil, an organosilicone adjuvant, into a tank mixture would improve performance of two neonicotinoids against weeping fig thrips. Tri-star and Marathon were applied with or without Capsil to foliage of weeping fig. Although these products are typically effective against thrips, we could not get comparable performance against weeping fig thrips despite the addition of an organosilicone adjuvant.

Nature of Work: Weeping fig thrips (*Gynaikothrips uzeli*), an exotic thrips species, are now reported from eleven states in the continental U.S., HI, Costa Rica, and Trinidad (1, 6) with more extensive problems in the Gulf states. The biology and identifying characters have been recently summarized (1, 7). In summary, adults are day active and easily monitored with yellow sticky cards. Adult feeding induces new foliage to fold along the midvein forming a gall. Galls are permanent and the foliage does not recover. Galls also provide a refuge for biological controls of this thrips, other pest thrips, scale insects, mealybugs, and may provide a means for other pests to move undetected across state lines (1).

Few insecticides are effective against weeping fig thrips (2). Surprisingly, systemic neonicotinoid insecticides applied to weeping fig for control of weeping fig thrips are ineffective when applied as a drench and foliar applications were only effective for 7 days after treatment (DAT). Decreased efficacy may be due to a lack of uptake of the active ingredient. We tested this hypothesis by comparing the efficacy of two neonicotinoid insecticides with or without Capsil (Scotts, Marysville, OH) a common adjuvant. Organosilicone adjuvants such as Capsil are reported to increase the penetration of active ingredients into plants allowing for more effective control of weeds, insects, and diseases (4).

These trials were conducted with plants growing in a greenhouse at the South Mississippi Branch Experiment Station in Poplarville, MS. Potted *F. benjamina*, 1.4 m tall, were spaced about 0.5 m apart on benches in the greenhouse. All plants were thrips free. Plants were watered with overhead irrigation supplemented with hand watering.

Imidacloprid (Marathon II, OHP, applied at 0.13 ml/liter) and acetamiprid (Tri-star, Cleary Chemical, applied at 0.25 g/liter) were selected to represent neonicotinoid insecticides of low or high water solubility respectively (5). Products were measured and added to 1 liter of water in separate 1 liter glass bottles. Two sets of bottles with either product were prepared as well as one bottle with just 1 liter of water. Capsil at 0.94 ml per liter was added to one bottle containing imidacloprid, one containing acetamiprid, and the water only bottle. The other bottles received nothing. This experiment had five treatments; two insecticides with and without Capsil, Capsil control, and an untreated control.

Each treatment was applied to runoff to the canopy of six separate plants (replicates) whereas six untreated plants grown under the same conditions were also used. At 7, 14, and 21 days after treatment, a cutting consisting of 2–3 leaves (5–7.5 cm long) was taken from each plant. Cuttings were selected to have succulent new growth as this is a preferred site for adult feeding and oviposition. Cuttings were kept hydrated by placing the base of each through a hole punched in the lid of a 118 ml cup filled with water. In the laboratory, each cutting was placed into a 355 ml translucent plastic cup and then infested with 10 adult thrips taken from a colony maintained in a separate greenhouse on potted weeping fig.
After a cutting was infested, the cup was covered with a 355 ml translucent plastic cup with a mesh-covered hole in the bottom, and sealed with parafilm. Cups were then placed on the lab bench under fluorescent lighting with a 14:10 (L:D) photoperiod. After 24 h, cups were opened and the number of dead and live thrips was recorded. Percent mortality data was calculated for each treatment. These data were arcsine square root-transformed to correct for heterogeneity of variances. Mortality data were analyzed using an analysis of variance (ANOVA) then subjected to Fisher's LSD for means separation.

Results and Discussion: Mortality of thrips exposed to imidacloprid or acetamiprid-treated foliage was greater than those exposed to untreated foliage at 7 DAT ($F = 9.04$; df = 5, 25; $P < 0.01$). At 14 DAT ($F = 1.19$; df = 5, 25; $P = 0.34$), mortality of thrips on plants treated with acetamiprid was significantly greater than those on control cuttings. By 21 DAT, mortality of thrips on any treatment was not different from controls ($F = 0.28$; df = 5, 25; $P = 0.92$).

Interestingly, the addition of a surfactant did not increase efficacy or residual control for the two neonicotinoids tested as suggested by Stevens (4). Insecticide resistance is not likely the reason for the lack of susceptibility of weeping fig thrips to most insecticides. A more plausible explanation is that current use rates are not high enough to control this pest. A study with Cuban laurel thrips, *Gynaikothrips ficorum*, compared the efficacy of five organophosphate insecticides over a range of concentrations. In that study, each product required the maximum concentrations, which were higher than label rates, to provide 100% mortality (3). The present study reiterates that weeping fig thrips are a difficult to control species using conventional insecticides at current label rates. To date, only bifenthrin provides significant mortality >14 DAT (2). However, this product may not be compatible with currently established biological controls (8).

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Table 1. Percent mortality of adult weeping fig thrips placed on cuttings from treated plants at 7, 14, and 21 days after treatment (DAT).

	Mean (± SE) Percentage Mortality[a] at		
Treatment	7 DAT	14 DAT	21 DAT
Untreated control	6.9 ± 3.4a	9.9 ± 3.5a	27.1 ± 11.1a
Adjuvant[b]	42.9 ± 12.4bc	26.6 ± 11.1ab	24.6 ± 12.7a
Imidacloprid[c]	40.0 ± 11.8b	33.3 ± 14.1ab	20.7 ± 9.4a
Imidacloprid[c] + Adjuvant[b]	44.4 ± 9.3bc	18.1 ± 3.7ab	15.1 ± 6a
Acetamiprid[d]	82.9 ± 3.2d	36.2 ± 13.9ab	21.1 ± 11.2a
Acetamiprid[d] + Adjuvant[b]	65.2 ± 11.2cd	39.9 ± 14.5b	30.2 ± 13.3a

[a] Mortality of adult thrips evaluated after a 24 h exposure to excised cuttings from treated plants in a laboratory assay.
[b] Capsil, Scotts, rate 0.94 ml per liter
[c] Marathon II, OHP, 21.4% [AI], rate 0.13 ml/liter
[d] Tri-Star, Cleary Chemical, 70% [AI], rate 0.25 g/liter

Host Plant Resistance of Dogwood Species to Feeding by Dogwood Sawfly Larvae

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Index Words: host plant resistance, integrated pest management, Hymenoptera, Tenthredinidae

Significance to Industry: Though dogwood sawflies (*Macremphytus tarsatus*) are typically minor pests of *Cornus* sp. in the southeastern U.S., both the wasp and its plant hosts occur throughout the eastern U.S. Aesthetic injury from larval sawfly feeding is frequent in northern states where native golden-twig, gray, and redosier dogwoods and non-native tatarian dogwoods are common. But expect to see more larval feeding injury in the southeastern U.S. as preferred *Cornus* host plants like ‘Flaviramea’ golden-twig, gray, and ‘Sibirica’ tatarian dogwoods increase in popularity and use. Foliar chemical constituents in corneliancherry, flowering, and kousa dogwoods appear to render these species unpalatable as *M. tarsatus* host plants.

Nature of Work: Tree and shrub forms of several *Cornus* species are reported as host plants for *Macremphytus* species sawflies (Hymenoptera: Tenthredinidae) (3, 4). Dogwood sawflies, *M. tarsatus* Say, are commonly encountered pest defoliators of dogwoods in northeastern and midwestern U.S. landscapes (1) and periodic pests in the southeastern U.S. (6) *Macremphytus* sawfly feeding is seldom sufficient to kill the host plant (1, 2, 5) but can cause extensive aesthetic injury to some species of dogwoods. Because susceptibility among dogwood species to larval feeding injury by *M. tarsatus* has not been tested, our research objectives were to identify potential host plant resistance in *Cornus* spp. by examining larval sawfly feeding preferences for ten commercially available dogwood species or cultivars and to examine chemical constituents of *Cornus* foliage related to host plant resistance.

In 2005 and 2006, *M. tarsatus* in their 7^{th} and 8^{th} juvenile stadia were collected in July from a mixed species collection of dogwoods (Table 1) grown without pesticides at the research nursery of The University of Tennessee in Knoxville ($35^{o}58'$ N x $83^{o}55'$ W). Larvae were subjected to host plant choice and no-choice lab assays. No-choice assays were conducted with seven replicates by exposing individual larvae to three 20 mm (0.79 in) diameter leaf disks for 48 h, after which leaf disks were replaced and left for another 48 h. Larval consumption of leaf disk area was visually estimated to the nearest 10 percent 12, 24 and 48 h after new leaf disks were provided. In choice assays, 15 larvae were introduced into each of 10 (2005) and 9 (2006) replicated 28.5 cm (11.25 in) diam arenas and provided

three 12 mm (0.47 in) diameter leaf disks per each of 10 dogwood types. Leaf disks were replaced three times at 24 h intervals, thus larvae were provided 10.2 cm^2 (1.58 in^2) total leaf area during the 72 h experiment. Leaf disk consumption was assessed as previously described 2, 4 and 24 h after new leaf disks were provided.
Estimated feeding injury value data were converted to mm^2 leaf tissue consumed from the total available leaf area and adjusted by arcsine transformation prior to statistical analyses. Data were subjected to analysis of variance (ANOVA) using PROC GLM in SAS. For all trials, experimental arenas were maintained under ambient environmental conditions (22 +/- 1C and 25 +/- 5% RH) with supplemental bench lighting to sustain a 16:8 L:D photoperiod. Prior to introduction into experimental arenas, larvae were held without food for 24 h.

To assess chemical differences among leaves of the tested dogwood species, 10 fully expanded, feeding injury- and disease symptom-free leaves were taken from several branches per dogwood type, frozen in liquid nitrogen, macerated and stored at –70°C. For each *Cornus* type, about 100 mg leaf powder was mixed with 1 mL methyl tert-butyl ether (MTBE), shaken at room temperature for 2 h, then centrifuged at 13,000 rpm for 2 min extract hydrophobic compounds from dogwood samples. After centrifugation, hydrophobic compounds of MTBE supernatants were analyzed using a Shimadzu gas chromatograph (Shimadzu, Kyoto, Japan) equipped with a SHR5XLB capillary column (30 m $\times$ 0.25 mm, thickness 0.25 μm) and a mass spectrometer (Shimadzu, Kyoto, Japan) with 1-octanol used as an internal standard. Foliage from each dogwood species was analyzed three times. Compounds were tentatively identified using the National Institute of Standards and Technology (NIST) mass spectral database. Concentrations in dogwood leaves were presented as µM 1-octanol equivalent (OE) per g fresh weight (FW) (Fig. 1).

Results and Discussion: Despite some variation at intermediate levels of foliar consumption between years and experimental trials, sawfly larvae showed clear preference and aversion toward certain dogwoods. These results were consistent in both choice and no-choice assays. Geographic origin of *Cornus* species did not reliably predict native *M. tarsatus* wasp host preferences (Table 1). *Cornus alba* 'Sibirica' from eastern Asia was most susceptible to dogwood sawfly feeding, after which U.S.-native *C. racemosa* and *C. sericea* 'Flaviramea' were most preferred. *Cornus florida*, *C. kousa*, and *C. mas* incurred only light feeding activity and appear to be resistant to *M. tarsatus* larval feeding. Indeed, these dogwood species are seldom observed to support sawfly populations in the southeastern U.S. By contrast, *C. alba* 'Sibirica', *C. racemosa*, and *C. sericea* 'Flaviramea' were heavily consumed, regardless of year and experimental run (Table 1).

The mechanism of resistance or susceptibility remains unclear but evidence from preliminary metabolic profiling suggests that presence and concentration of certain hydrophobic compounds in leaves of *Cornus* species may be important. In particular, peaks 1, 2 and 5 appear to influence sawfly preference and were either absent, or present in smaller concentrations in resistant *C. florida*, *C. kousa*, and *C. mas* dogwoods than in susceptible *C. alba* 'Sibirica' and *C. racemosa* species (Fig. 1). This trend was not consistent for *C. sericea* 'Flaviramea' leaves, which yielded smaller peaks 1 and 5 and no peak 2, yet were highly preferred by larval sawflies.

Finally, greater larval sawfly preference for 'Flaviramea' golden-twig dogwood foliage (*C. sericea* 'Flaviramea') than for leaves of the red-stemmed redosier dogwood (*C. sericea*) is not readily explained by hydrophobic compound concentrations in leaf tissues (Fig. 1). Instead, interactions with other metabolites (e.g., hydrophilic compounds excluded in our analysis) or synergism between multiple compounds may affect palatability of dogwood species to *Macremphytus* sawflies. Additional effort will be needed to confirm chemical names and structures of individual peaks tentatively provided by the NIST database. Regardless, GC/MS offers a potential pathway for identifying chemical constituents that contribute to sawfly resistance in *Cornus* sp.

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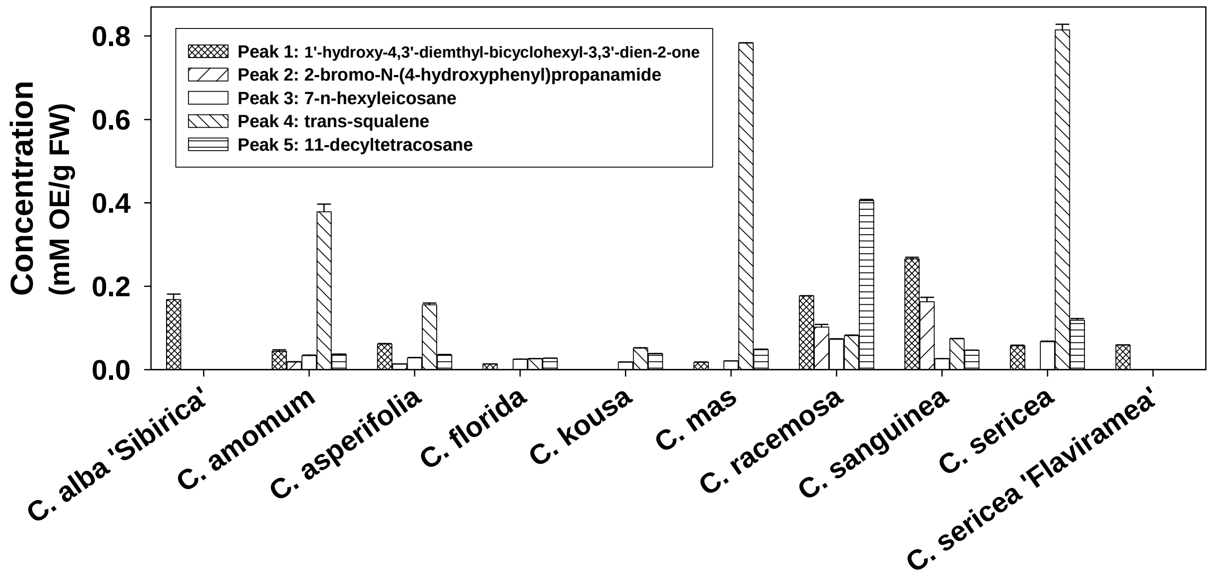

Fig. 1. Relative concentrations, compared to a 1-octanal internal standard, of five key peak chemistries that varied among leaves of 10 tested dogwood species.

Table 1. Native range and dogwood species or cultivars assayed for host plant suitability to *M. tarsatus* larval feeding.

Species / Cultivar (Taxonomic authority)[1]	Common name	Geographic nativity	Relative host suitability [2]
Cornus alba 'Sibirica' L.	Tatarian dogwood	Eastern Asia	VS
C. amomum Mill.	Silky dogwood	Eastern USA	MS
C. asperifolia Michx. var. *drummondii* (C.A. Mey)	Roughleaf dogwood	Eastern USA	MR
C. florida L.	Flowering dogwood	Eastern & Central USA	VR
C . kousa (Buerger ex Miq.) Hance	Kousa dogwood	Eastern Asia	VR
C. mas L.	Corneliancherry dogwood	Europe & Western Asia	VR
C. racemosa Lam.	Gray dogwood	Eastern & Central USA	VS
C. sanguinea L.	Bloodtwig dogwood	Europe	MS
C. sericea L. (formerly *C. stolonifera* Michx. f.)	Redosier dogwood	Widespread USA	MR
C. sericea 'Flaviramea' L.	Golden-twig dogwood	Cultivated US native variety	VS

[1] From Dirr, M.A. 1998. Manual of Woody Landscape Plants, 5th Ed., Stipes Publ., Champaign, IL.
[2] "VR" = very resistant; "MR"= moderately resistant, "MS" = moderately susceptible, "VS" = very susceptible based on consistency among tests for mean leaf area consumed by individual *M. tarsatus* larvae during repeated 72 h no-choice assays.

Evaluation of Biorationals for Ornamental Pest Control

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Index Words: Chrysanthemum aphids, IPM, Biorationals, Insecticides, Aria, TriCon, MilStop, Capsil, and QRD400.

Significance to Industry: Biorational insecticides are insecticides that are efficacious against a target pest but are less detrimental to natural enemies. Many integrated pest management program are based on the use of these products. This study evaluated the efficacy of Aria, QRD 400, TriCon, MilStop and the surfactant Capsil for their ability to control chrysanthemum aphids on chrysanthemums. The TriCon, Milstop, QRD 400, and Capsil reduced the aphid populations after two applications. On day eight, the TriCon and Milstop treatments resulted in the lowest aphid populations. By seven days after treatment, the Aria application resulted in a reduction of aphids compared to the untreated control, but it did not reduce the aphids to an acceptable level. This may be because in this study the lowest rate of Aria was evaluated and a rate higher than 20 gram / 100 gal may be required to effectively control chrysanthemum aphids. It is important to note that Capsil is a spreader sticker and MilStop is a fungicide.

Nature of Work: Historically, many of the insecticides used by ornamental producers were broad-spectrum insecticides that indiscriminately killed both beneficial and pest arthropod. While some growers lament the loss of these products, many growers are developing integrated pest management programs relying on the use of biorational pesticides. Biorational insecticides are insecticides that are efficacious against a target pest but are less detrimental to natural enemies. There are a wide range of insecticides that are considered biorational, these can include: soaps, oils, botanicals, systemic insecticides, insect growth regulators and insect pathogens.

In this study I evaluated Aria, QRD 400, TriCon, MilStop and the surfactant Capsil for their ability to control chrysanthemum aphids on chrysanthemums. QRD 400 (AgraQuest, Inc.) is a plant extract derived from *Chenopodium ambrosioides* var. *ambrosioides*. The extract works by several modes of action to control a broad range of soft-bodied insects. TriCon (BioWorks, Inc.) is a blend of borax, orange oil and biodegradable surfactants. MilStop (BioWorks, Inc.) is a potassium bicarbonate based, broad-spectrum foliar fungicide. Although MilStop is not a registered insecticide, growers have observed reduction of aphids and whiteflies after its use. This control is most likely due to other ingredients in the formulations besides the potassium bicarbonate. Aria (flonicamid, FMC Inc.) is a new class of chemistry that prevents insects from feeding. The insect dies from dehydration and starvation. Aria is efficacious against sucking insects only. Capsil Spray Adjuvant (Scotts Company) is an organosilicone adjuvant widely used by ornamental growers together with pesticides.

Biorationals were evaluated for their ability to control chrysanthemum aphids, *Macrosiphoniella sanborni*, on chrysanthemums “Charm”. The trial was conducted in a greenhouse at the Texas A&M University System Agricultural Research and Extension Center at Overton, TX. Chrysanthemum plants were grown with a single plant in a 4-inch pot contained a natural infestation of chrysanthemum aphids.

Plants were set up in a randomized complete block design with six replicates. Foliar treatments were applied using an R & D® CO2 backpack sprayer with an 8002VS tee-jet flat spray nozzle at 60 psi. All the treatments except Aria were applied on day 0 and 7. Aphids were counted before treatment and 24 hours after each treatment. Numbers of chrysanthemum aphids were counted at each sample period on five terminal chrysanthemum leaves. The following treatments were evaluated (amt. product / 100 gal): TriCon (0.4 gal / 100 gal), TriCon (0.8 gal / 100 gal), MilStop (2.5 lbs / 100 gal), MilStop (5.0 lbs / 100 gal), Aria (20 g / 100 gal), QRD400 (1 gal / 100 gal), Capsil (7.5 fl oz / 100 gal), and water.

A logarithmic transformation [log10 (x+1)] of the data was used to make the variance independent of the means. Data on the efficacy of the treatments were subjected to analysis of variance (Randomized Complete Block AOV, Statistix 8). Means separation was accomplished by using the Tukey’s HSD test at the $P<0.05$ level. All data are presented as untransformed means.

Results and Discussion: TriCon, Milstop, QRD 400, and Capsil reduced the aphid populations after both applications (Table 1). Aphids that the survived the treatments most likely did not come into contact with the insecticide applications. On day eight, the TriCon and Milstop treatments resulted in the lowest aphid populations. A second application at a closer time interval may help eliminate any aphids that survived the first spray before they are able to reproduce. By seven days after treatment, the Aria application resulted in a reduction of aphids compared to the untreated control, but it did not reduce the aphids to an acceptable level. This is may be because the lowest rate of Aria was evaluated and a rate higher than 20 gram / 100 gal may be required to effectively control chrysanthemum aphids. It is important to note that Capsil is a spreader sticker and MilStop is a fungicide and they are not registered as insecticides. No phytotoxicity was observed with any of the treatments.

Acknowledgements: Yoder Brothers donated the chrysanthemums used in the study.

Table 1. Mean number of chrysanthemum aphids per five chrysanthemum leaves.

		Days After First Treatment			
Treatment	Rate	0	1	7	8
TriCon	0.4 gal	64.2 ± 10.2 a	0.2 ± 0.2 e	2.2 ± 1.2 c	0.0 ± 0.0 c
TriCon	0.8 gal	83.3 ± 9.7 a	5.8 ± 2.5 bc	8.8 ± 1.4 bc	1.3 ± 0.9 c
Milstop	2.5 lbs	72.8 ± 9.3 a	0.5 ± 0.3 de	13.3 ± 5.0 b	0.5 ± 0.3 c
Milstop	5.0 lbs	69.2 ± 8.1 a	2.2 ± 1.0 cde	17.3 ± 7.8 bc	0.8 ± 0.8 c
QRD400	1 gal	111.2 ± 14.1 a	4.2 ± 1.6 cd	29.5 ± 11.8 b	18.8 ± 10.1b
Capsil	7.5 fl oz	90.7 ± 10.5 a	13.3 ± 3.3 b	34.5 ± 6.8 ab	12.8 ± 3.9 b
Aria	20 g	90.0 ± 11.6 a	58.0 ± 13.4 a	18.8 ± 3.2 b	28.2 ± 5.7 b
Water		83.5 ± 15.0 a	71.2 ± 10.6 a	143.2 ± 25.9 a	181.0 ± 27.8 a

Means within column followed by the same letter are not significantly different (Tukeys HSD, P>0.05).

Fire Ant Management in Urban Landscapes with Broadcast Treatments

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Index Words: red imported fire ant, *Solenopsis invicta*, nursery insect pest, chemical control, residual control

Significance to the industry: Fire ants are a serious pest in nursery production. They are difficult to control, rapidly re-establish after control, and they must be controlled in plant materials before the plant materials can be shipped out of the quarantine areas. They feed on nursery plants but cause minimal plant feeding. Additionally, they can seriously impact handling of plant materials, because of their aggressive stinging and defense of their colonies. Worker complaints and injuries can be a significant impact on general operations of the nursery.

Nature of Work: The red imported fire ant (RIFA), *Solenopsis invicta* Buren, is one of the most destructive insect pests in the urban/suburban landscape. RIFA thrive in disturbed habitats and quickly invade these areas whether the disturbance is natural or man-made. RIFA was introduced into the Mobile, AL area from South America in the 1920s and rapidly spread across the southeastern U.S. It has now spread from coast to coast across the southern states and infests over 330 million acres. The total annual cost due to damages and expenditures for control for RIFA within Texas ~~alone~~ was estimated at $1.2 billion for 1998 and the cost is increasing each year (4).

Fire ant baits are normally effective as mound control because the workers collect the bait and distribute it within the entire colony to all stages including the queen (3). Baits containing indoxacarb have been shown to cause colony decline within 24-78 h, (1). Fire ant control is generally aided by both passive and active contact with the chosen insecticide (2). Currently marketed insecticides for the management of fire ants do not repel fire ants and therefore allow both passive and active contact as workers forage and construct colonies. Comparisons between long-lasting-slow-acting control methods and fast-acting-short-residual control products are needed to compare the efficacy of each product versus the time to begin control and the length of time of actual control. These types of studies provide efficacy data to make recommendations for nurserymen, homeowners and turf managers on golf course and sports field based on the type of control immediately desired to meet their environmental and sociological needs.

This experiment was initiated to compare the effectiveness of broadcast treatments of several fire ant control products in the urban landscape. The test compared a bait formulation of indoxacarb (Spectracide, Once 'N Done) with contact granular formulations of fipronil and bifenthrin (Over N' Out and Ortho Max Fire Ant Killer, respectively). Also, three alternate formulations of Over N' Out (fipronil) were compared with the commercial Over N' Out product.

This experiment was established on the grounds of a community college in north Dallas, TX on 1 June 2006. Plot sizes were delineated by the number of active mounds and ranged from 240 to 2,860 m^2 [mean = 780 m^2 (8,400 ft^2)]. Each plot had at least 10 (up to 18) active mounds. All mounds were first flagged and the plot was terminated either 4.6 m past the last mound or at the nearest barrier such as a sidewalk. Plots were delineated with white turf marking paint on two sides and bordered on at least two sides by concrete curbs.

Granular treatments were applied using walk-behind fertilizer spreaders of either a Scott's Pro Turf Professional Drop Spreader (Scotts, Marysville, OH) or a Spyker Cyclone Spreader Model # 34B7 (Spyker Spreaders, Urbana, IN). Both spreaders were calibrated just before applications were made using blank granule formulations of each product. A belly bumper was used to apply the bait treatments.

For all plots receiving a granular treatment, the perimeter of the plot was first ringed with one pass (ca. 1 m wide) application from the Scotts drop spreader, and the remainder of the plot was then treated with the Spyker Cyclone Spreader. This approach was important since well over half of the RIFA mounds in these plots were established at the curb/turf interface. No irrigation was applied the evening after treatments, but all plots were irrigated with 0.33 inch of water the following evening. Thereafter this area was put on water rationing and only ca. 0.84 cm of water was applied weekly instead of the 1.3 cm (0.5 inch) or more required to maintain good turf cover.

A pre-count of the number of live mounds and an assay of the foraging activity was completed before treatments. Each live colony was marked ca. 30 cm from the mound by spraying a white X on the turf, so the colony could be easily found for the next assay. Mounds were recorded as active if RIFA workers emerged from the mound when it was probed with wire end of a flag. Pretreatment foraging activity of ants within each plot was assayed by placing five, 8-dram shell vial traps near the central area of the plot for ca. 30 to 50 min exposure. Vials were baited with ca. 1/10 (ca. 1.5-1.8 g) of hot dog (processed meat sausage) and placed no closer than ca. 1 m from the nearest active RIFA colony. After exposure, vials were collected, closed with a rubber stopper, and transported to the laboratory for counting.

In the laboratory, the three tubes with the largest number of ants were counted for each plot. Vials were flooded with 95% ethanol, emptied into 10 cm diam Petri dishes, and the ant counts recorded. All vials with greater than 200 ants were recorded as only 200 for the sample. Plots were divided into four replicates based upon pretreatment counts of foraging ants. Treatments were randomly assigned within each replicate. This method clustered plots with similar foraging activity into groups.

Foraging activity was assessed 1 or 2 d before treatments were applied and at 3 days after treatment (DAT), then 1, 2, 3, 6, 12 and 52 weeks after treatment (WAT). Individual mound mortality was determined as the number of active mounds before and at 5, 10 and 50 WAT by probing each mound with a wire flag. When the test area was dry, a 1.5 g piece of hot dog was also dropped on those mounds that did not express workers and observed 20-30 min later to confirm mortality. If the colony was active, workers would forage for the hot dog pieces within this time period.

Statistical Analysis - Transformations (arcsin + 0.01) were used to achieve normality and homoscedasticity before analysis (7) but untransformed means are presented. Analysis of variance (ANOVA) for a randomized complete block design was performed to test the differences between treatments, and means were compared using Fisher's least-significant difference (LSD; $P < 0.05$) multiple range test (6).

Results and Discussion: Foraging at Bait Tube Stations - Among the six treatments, Spectracide Once & Done (indoxacarb) provided immediate suppression and control of the foraging ants (Fig. 1). Bait trap samples were reduced to an average of less than two ants per bait tube/plot within 3 DAT. Trap samples remained ≤17.7 ants until 6 WAT (30.3 ants per bait tube/plot) when trap samples began to increase and remained at 43.5 ants per bait tube/plot at 52 WAT. All formulations of the Over N' Out (fipronil) significantly reduced the numbers of foraging ants trapped. The highest initial reduction in foraging ants was produced by formulations with Substrate-2 with little difference in the level of control due to the two Solvents by 12 WAT. However by 52 WAT, all formulations of Over N' Out had reduced the number of foragers to ≤5.3 ants per bait tube/plot and the two formulations with Solvent-D each reduced the number of foragers to zero. Plots treated with Ortho Max Fire Ant Killer (bifenthrin) never reduced the number of foragers below 100 ants per bait tube/plot during the first 12 WAT but populations of foragers were reduced to 50.8 ants per bait tube/plot by 52 WAT. In a previous study, both broadcast and individual mound treatments with Talstar, another formulation of bifenthrin, provided excellent control for at least 6 WAT (5). Populations trapped in the untreated check plots remained ≥150 ants per bait tube/plot throughout the 52 week test.

Reduction in Number of Active Colonies - At the initiation of this study, there were an average of 13.8 active colonies per plot with a range of from 10 to 21 colonies depending on the colony density and size of the plot. Ortho Max Fire Ant Killer provided 56.9% reduction of active colonies at 5 WAT, but only a 10.6 and 28.9% reduction at 10 and 50 WAT, respectively. All formulations of Over N' Out provided from 52.0 to 72.2% reduction of live colonies at 5 WAT, but each provided >81% by 50 WAT. Spectracide Once & Done provided the highest initial colony reduction of 95.1% at 5 WAT, but fell to 69.4% by 50 WAT. During the test period, 37.6 and 7.9% of the colonies in untreated check plots were lost at 5 and 10 WAT respectively, but by 50 WAT only 60 % could be found that were still alive. Throughout the test period, the turf in these plots received minimal irrigation and was dry. An accurate assay of mound activity could not be recorded after 10 WAT until we had substantial rainfall in May. These rains allowed us to make a good assay of mounds that were still alive within the plots at 50 WAT. This data confirmed the long residual control provided by the fipronil in other experiments.

Test Conditions and Impacts - The slowness of control activity exhibited by treatments in this experiment can partially be attributed to the severe drought and watering restrictions experienced in the Dallas area during 2007. Essentially no rainfall was recorded during most of the test period. This may have limited the release of toxicant from the granular formulations and either curtailed or delayed potential control of the RIFA until the rainfall at the end of the test.

Another factor and a recommendation supported by previous experiments (JAR), by this experiment, and likely also to be supported by future research is to treat RIFA colonies along concrete curbs, sidewalks and other hard surfaces or against buildings or other structures in differently than colonies that are surrounded entirely by turf. These colonies require special attention either by applying an increased application rate (double pass) of the granular insecticide treatments along the hard surfaces, applying an additional bait application in these areas or by a follow-up application of the granules. In urban areas, such as this test area, a high percentage of the RIFA colonies (over half in this experiment) are situated at the curb/turf interface. These are more difficult to bring under control compared to colonies situated in an open turf area where the granular treatment can be applied on all sides of the colony. Along these hard surfaces, unless one makes a full coverage application to these interface areas, many of the colonies will escape full exposure to the toxicants.

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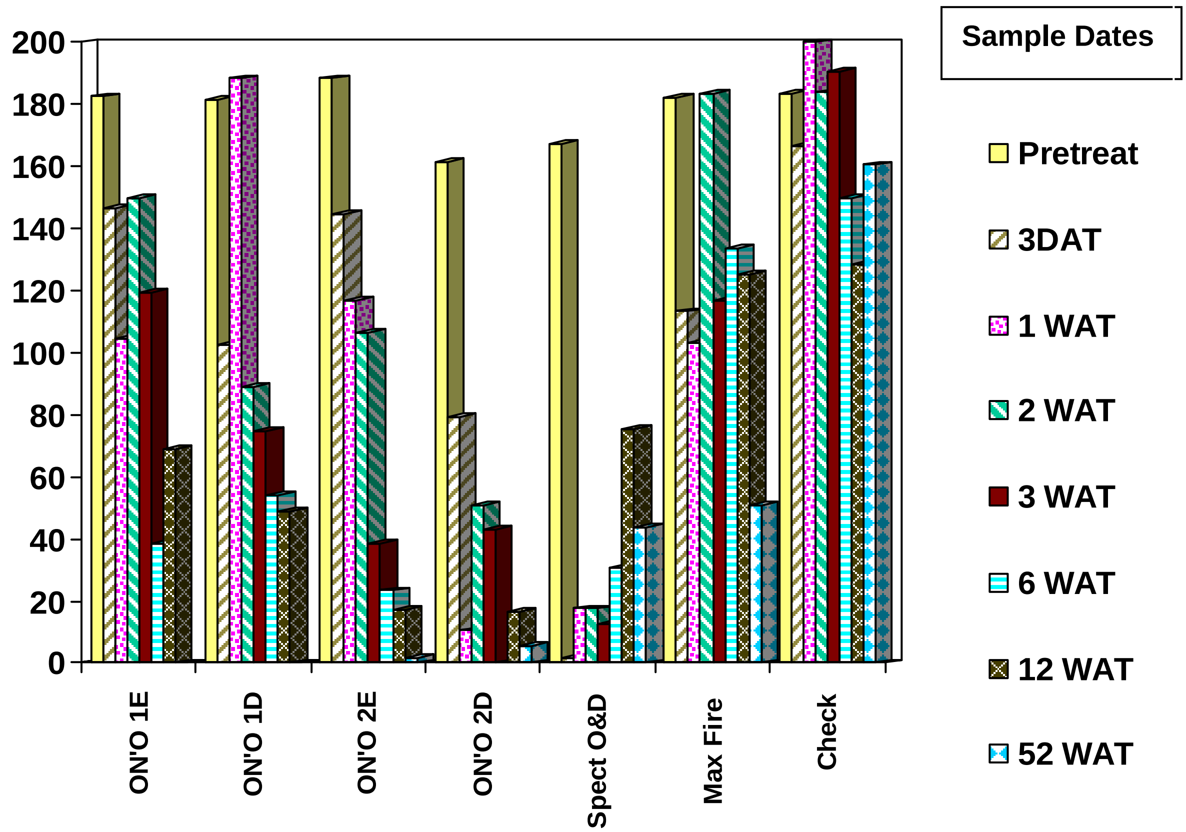

Legend: ON'O 1E = Over N' Out (Sub 1: Sol E) (fipronil); ON'O 1D = Over N' Out (Sub 1: Sol D); ON'O 2E = Over N' Out (Sub 2: Sol E); ON'O 2D = Over N' Out (Sub 2: Sol D); Spect O&D = Once & Done (Spectracide) (indoxacarb); Max Fire = Ortho Max Fire Ant Killer (bifenthrin).

Figure 1. Mean number of ants trapped per bait tube/plot for each treatment at pretreatment, 3 DAT and at WAT.

Table 1. Treatments and rate of application.

Fire Ant Control Product	Active ingredient	Formulation	Application Rate[c] lb product/1,000 ft^2	kg product/ha
Over N' Out (Sub 1: Sol E)[ab]	fipronil	0.0103 G	2.0	97.6
Over N' Out (Sub 1: Sol D)[a]	fipronil	0.0103 G	2.0	97.6
Over N' Out (Sub 2: Sol E)[a]	fipronil	0.0103 G	2.0	97.6
Over N' Out (Sub 2: Sol D)[a]	fipronil	0.0103 G	2.0	97.6
Ortho Max Fire Ant Killer	bifenthrin	0.2 G	2.3	112.2
Once & Done (Spectracide)	indoxacarb	0.016 B	0.5	24.4
Untreated Check				

[a] Substrate 1 = Biodac; Substrate 2 = Ecogran; Solvent E and D are proprietary formulations.
[b] Commercial standard for Over N' Out.
[c] To convert from kg/ha to lbs/1000 ft^2 divide kg/ha by 48.91.

Table 2. Mean number of active fire ant colonies in plots at pretreatment and at WAT and the percentage reduction provided by each treatment.

Treatment [a]	Live colonies/plot (% reduction) Pretreatment	5 WAT [b]	10 WAT [b]	50 WAT [b]
ON'O 1E [c]	13.0 a [d]	3.7 (72.2) b	11.3 (13.1) bc	3.0 (75.6) ab
ON'O 1D	14.7 a	7.3 (52.0) bc	14.7 (2.0) c	2.7 (81.2) a
ON'O 2E	14.7 a	5.3 (64.3) bc	13.0 (11.4) bc	1.3 (90.2) a
ON'O 2D	14.7 a	7.0 (53.3) bc	11.3 (22.8) b	2.3 (82.4) a
Max Fire	14.3 a	6.3 (56.9) bc	13.0 (10.6) bc	10.3 (28.9) c
Spect O&D	14.3 a	0.7 (95.1) a	9.0 (37.1) a	4.3 (69.4) ab
Untreated Ck	13.7 a	8.3 (37.6) c	13.0 (7.9) c	8.7 (39.7) bc

ON'O 1E = Over N' Out (Sub 1: Sol E) (fipronil); ON'O 1D = Over N' Out (Sub 1: Sol D); ON'O 2E = Over N' Out (Sub 2: Sol E); ON'O 2D = Over N' Out (Sub 2: Sol D); Spect O&D = Once & Done (Spectracide) (indoxacarb); Max Fire = Ortho Max Fire Ant Killer (bifenthrin). Substrate 1 = Biodac; Substrate 2 = Ecogran; Solvent E and D are proprietary formulations.
[b] Percentage reduction = (no. of active colonies at WAT / no of active colonies at start of test).
[c] Commercial standard for Over N' Out.
[d] Means in the same column followed by the same letter are not significantly different by Duncans mean separation (*P* = 0.05)

Fertilization Affects Susceptibility to Western Flower Thrips, Herbivore Abundance, Growth, Development, and Quality of *Gerbera jamesonii*

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Index Words: *Gerbera jamesonii*, Western flower thrips, phenolics, fertilization, resistance

Significance to Industry: 'Festival Salmon' gerberas were fertilized with 0, 30, or 100% of recommended fertilization rates and inoculated with ± five female adult western flower thrips (WFT). Susceptibility to WFT was reduced in gerberas receiving 0% and 30% of the recommended fertilization rate, low fertilization (LF) and moderate fertilization (MF) rate, respectively. There were very few WFT that survived on the LF plants, likely due to both the higher concentrations of defensive compounds (e.g. phenolics) and the low nutritional value of the LF tissue. Moderately fertilized (MF) gerberas also had reduced biomass and greater phenolic concentrations compared to HF plants, but these plants were not chlorotic, and MF plants without WFT were rated as marketable. Reducing fertilization by 70% (MF plants) did not affect flower dry mass or the rate of flowering (days to pollen shed), and the flower stalks (peduncles) were higher in response to the fertilizer reduction. Plants grown under LF rates were not marketable and growing plants with nutrient deficiencies is not feasible for production practices. Reducing fertilization between MF and HF levels may be a useful cultural management technique as part of an integrated pest management system for potted or cut flower gerbera production that enhances crop resistance and decreases pesticide applications for WFT.

Nature of Work: *Gerbera jamesonii* is an economically important floriculture crop that is sold as cut flowers, bedding plants, or as a potted flowering plant. Unfortunately, gerberas make excellent hosts for insect pests, especially western flower thrips [(WFT) *Frankliniella occidentalis* Pergande]. Gerberas have even been suggested for use as a 'trap crop' for managing WFT (1). WFT are difficult to control because of their small size, ability to reproduce to high numbers, cryptic behavior, egg deposition inside plant tissue, and propensity to secrete themselves in tight spaces. Also, WFT appear to have a propensity for becoming resistant to insecticides (4, 6). To avoid the development of insecticide resistance, producers need to reduce their reliance on pesticides and develop alternative management strategies. Ideally, an integrated pest management

(IPM) system that combines host plant resistance, cultural practices, biological control, and chemical control should be employed to control WFT in greenhouse production. Augmenting fertilization is one cultural practice that may influence host quality for WFT and reduce insecticide applications.

Many insect herbivores are more prolific on plants treated with higher nitrogen (N) fertilization. High fertility has been shown to increase the productivity of WFT on chrysanthemum (2, 3) and tomato (7). Reduction in WFT abundance in response to lower fertility regimes has been attributed to the reduced availability of essential nutrients for WFT, and possibly secondary metabolites. However, the effect of fertilization on natural defense mechanisms (e.g. secondary metabolites) was not measured in any of these studies. Secondary metabolism is thought to produce compounds which can be accumulated, so that when attacked, the plant has the means to deter, or kill herbivores. Toxic compounds, such as phenolics, can poison generalist herbivores and force specialist herbivores to invest resources in detoxification mechanisms that in turn incur growth and development costs (5).

In ornamental greenhouse production, there is a low threshold for insect pests, including WFT, because the aesthetic quality of the whole plant is the selling point. The objectives of this study were to determine the effects of fertilization on WFT abundance, and to characterize the effects of fertilization and WFT feeding on various plant growth and physiology characteristics. The effects of fertilization and WFT feeding on gerbera plant quality was also determined to assess the viability of altering fertilization in order to increase host plant resistance in gerbera.

Thirty gerbera (*Gerbera jamesonii* 'Festival Salmon') seedlings were grown in growth chambers with Sunshine Mix #1 as potting media. Each pot was enclosed in a large acetate cylindrical cage and half of the plants were inoculated with five adult female western flower thrips (WFT). Plants were fertilized as needed with 200 mL of Peters Professional Peat-lite special 15-16-17 at 0 (de-ionized water), 60, or 200 ppm N, which are respectively, 0, 30, or 100% the recommended rate. The three different concentrations of fertilizer represent low fertilization (LF), moderate fertilization (MF, 60 ppm N), or high fertilization (HF, 200 ppm N). The LF rate was only supplied with initial fertilizer charge present in professional growing media (5-6-12 fertilizer incorporated at 2.7 lbs/yd^3 of mix).

The experiment was terminated after 53 days and WFT populations, plant biomass, leaf area, chlorophyll content, and flower production were determined. Rate of flower development was determined by recording the number of days from transplanting to pollen shed of the most mature flower. The DM of peduncles per individual open flower was determined to demonstrate the phenotypic plasticity of plants under different fertilization regimes. Gerberas were rated for quality, based on the following scale: 1 = very poor, unsaleable; 2 = poor, unsaleable; 3 = average, saleable; 4 = good, saleable; 5 = excellent, saleable. Net photosynthesis, stomatal conductance, and total phenolic concentration of mature leaves were also determined at the end of the experiment.

The experiment was arranged in a 3 × 2 factorial. There were five replications arranged in a completely randomized design. Data were compared using analysis of variance (ANOVA), with fertilization, WFT, and fertilization × WFT as main effects. WFT infested and uninfested (control) plants were grown in two separate chambers to avoid cross-contamination. The experiment was repeated and chambers switched between WFT treatments to avoid possible chamber effects. The experiment was repeated twice but only results from the second experiment are presented as they represent the results from the first experiment.

Results and Discussion: The total number of WFT increased at higher fertility levels from 1.1 on LF plants to 77.7 on HF plants ($P < 0.0001$; Figure 1). Many WFT were unable to survive on the LF plants – three of five LF plants inoculated with WFT had no surviving WFT remaining and dead WFT were observed on leaf surfaces of the LF plants. The LF plants, those with only the initial fertilizer charge present in commercial media, were noticeably stressed. This caused a shift in carbohydrates from primary to secondary metabolism, as determined by the lower plant biomass and higher phenolics compared to higher fertility plants. MF plants averaged 52.1 WFT, which is a 33% reduction in total WFT population compared to HF plants. MF gerberas had greater phenolic concentrations compared to HF plants, but these plants were not visually stressed, and MF plants without WFT were rated as marketable (Figure 2). MF and HF plants had similar flower DM, flowered at approximately the same time, and flower stalks (peduncles) were actually higher in MF plants. On the other hand, leaf area, chlorophyll content, photosynthesis, stomatal conductance, vegetative DM, and total aboveground DM were reduced in MF (and LF) plants, compared to HF plants. WFT feeding decreased the SLA of HF and MF plants, indicating that leaves were thicker in response to WFT feeding. The MF plants without WFT were not as commercially acceptable (Figure 2) as the HF plants without WFT—due mostly to reduced chlorophyll content of the leaves.

Even though WFT populations were reduced by lowering fertilization, they were still not at an acceptable level in the MF plants. Chemical control would likely be needed to produce commercially acceptable potted gerberas, but moderately fertilized gerberas may require fewer pesticide applications compared to gerberas fertilized with higher rates. Ideally, reducing fertilization would just be one strategy that is incorporated into a comprehensive IPM system. Gerbera cut flower IPM programs in some nurseries use a wide variety of insect predators for biological control in conjunction with biorational insecticides. Reducing fertilization may be another tool that can be used to keep pest populations low, while still maintaining high quality.

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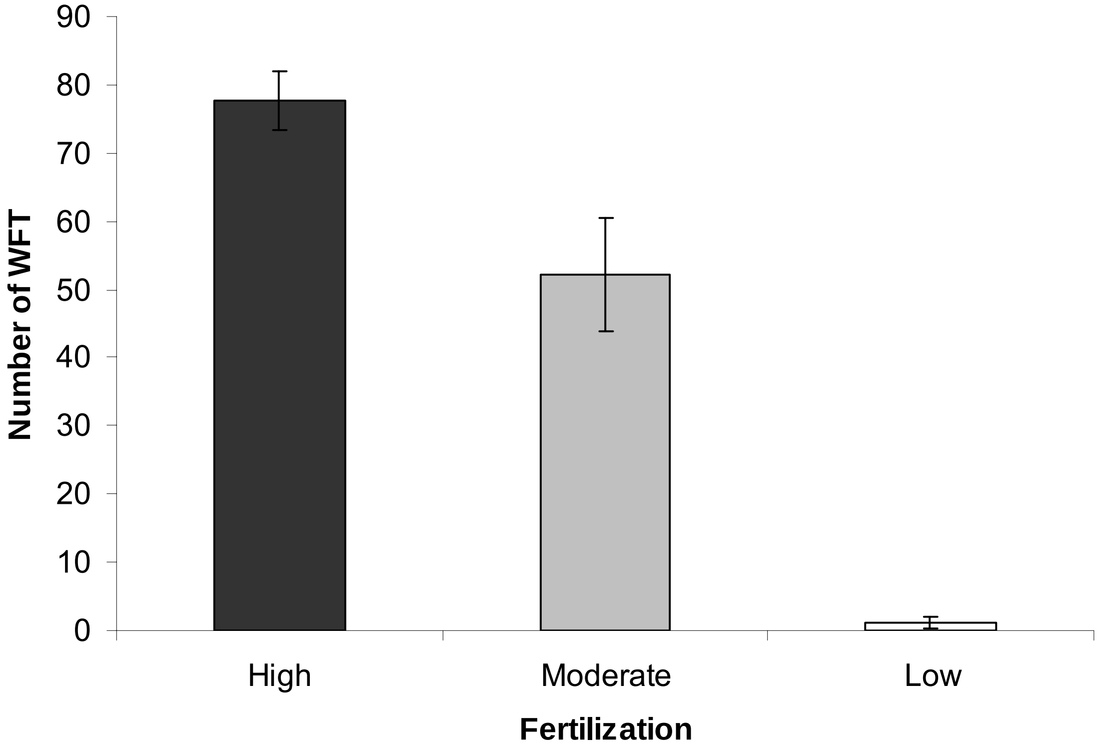

Figure 1. The total number of western flower thrips [(WFT) *Frankliniella occidentalis* (Pergande)] on *Gerbera jamesonii* 'Festival Salmon' treated with three different fertilizer concentrations. Fertilization was a significant main effect ($P < 0.0001$). Bars ± SE, n = 5.

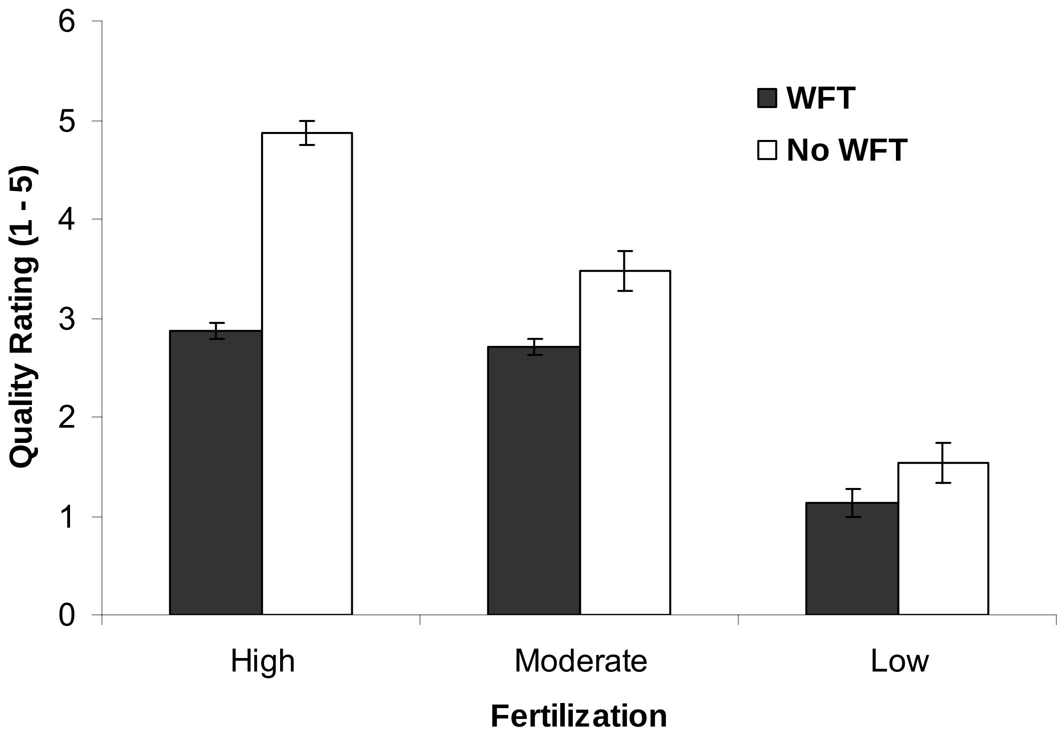

Figure 2. The overall quality of *Gerbera jamesonii* 'Festival Salmon' inoculated with western flower thrips (WFT) or without (No WFT), treated with three different fertilizer concentrations. Statistical significance for the quality rating was determined with a two-way ANOVA design for ranked data—the Scheirer-Ray-Hare extension of the Kruskal-Wallis Test. Fertilization ($P < 0.0001$), WFT feeding ($P \leq 0.0001$), and the interaction Fertilization × WFT ($P \leq 0.0014$) were significant main effects. Bars ± SE, n = 5.

Mortality of *Montandoniola moraguesi* following treatment of *F. benjamina* for control of weeping fig thrips

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Index Words: *Montandoniola moraguesi*, natural predators, *Gynaikothrips uzeli, Ficus benjamina*

Significance to the Industry: *Ficus* is one of the most widely produced foliage plants for commercial interiorscapes and consumer markets. Weeping fig thrips (*Gynaikothrips uzeli*) are major pests of *Ficus*, which induce leaf galls on the newly developing foliage. The anthocorid, *Montandoniola moraguesi*, is a specialist predator of weeping fig thrips. This predator enters the galls of *Ficus* and feed on thrips, which in turn helps to lower the populations. One limitation on the success of anthocorid predators are their susceptibility to foliar-applied insecticides like those used to prevent gall formation by weeping fig thrips. The objective of this study was to determine the susceptibility of *M. moraguesi* to bifenthrin applied for control of weeping fig thrips. Although bifenthrin is the best compound for control of weeping fig thrips, a single application results in significantly mortality of *M. moraguesi* for up to 6 weeks.

Nature of Work: Insect and mite pests attacking ornamentals have associated predators and parasites which act to reduce pest abundance. Success of these natural enemies often depends on using pesticides that are compatible with or 'softer' on beneficials (3, 5). As a result, insecticides should be evaluated for efficacy against pests as well as compatibility with key biological controls in order to establish an integrated pest management program. For this reason, we evaluated mortality of *Montandoniola moraguesi* (Hemiptera: Anthocoridae), a predator of several species of gall-forming thrips (1), following a foliar application of bifenthrin. Products containing bifenthrin are the most effective against *G. uzeli.* A single foliar application can protect leaves from being galled for up to 14 days after treatement (DAT), and effectively kill all life stage of thrips inside established galls for 7 DAT (2).

A colony of *M. moraguesi* were maintained on galled cuttings of *F. benjamina* infested with *G. uzeli*. This experiment was conducted using six *F. benjamina* plants growing in the greenhouse at the Southern Horticultural Laboratory (USDA, ARS) in Poplarville, MS. Each plant was sprayed to runoff with bifenthrin (Talstar, FMC Corp. Philadelphia, PA) at a rate of 12.5 ml per liter of water plus 0.94 ml per liter of adjuvant (Capsil, Scotts, Marysville, OH). Six other *F. benjamina* in the same greenhouse were left untreated as controls. Plants in this study were only treated once during the entire experiment.

At 1 DAT, three uninfested cuttings with two leaves each were then taken from each plant. The stem of each cutting was pushed through a small hole in the lid of a 30 ml plastic cup. The cup was filled with distilled water to keep the cutting alive during the experiment. Cuttings were then taken back to the laboratory and placed in 473 ml plastic cup. One *M. moraguesi* was then placed on the leaves of each cutting using a small moist paint brush. A second 473 ml plastic cup, vented with a small, mesh-covered hole on the bottom, was placed on top of the cup with the cutting and sealed with parafilm. After 24 hours of exposure, cups were opened and *M. moraguesi* were checked for mortality. Thereafter, cuttings were taken every seven days for 63 days and challenged with one *M. moraguesi* per cutting as described.

For each post-treatment sample (e.g., 1, 7, 14 DAT) percent mortality was calculated for *M. moraguesi* on control and treated cuttings. These data were arc sin sqrt transformed before being subjected to a repeated measures analysis of variance. Data for each sample period were then subjected to a two-sample *t*-test to determine treatment effects.

Results and Discussion: In the repeated measure ANOVA across all sample dates, the effect of time and treatment were significant (F = 2.07 and 59.36, P = 0.053 and 0.000, respectively), but no interactions of time, treatment, or replicate were significant (P >0.05). Within sample dates, mortality of *M. moraguesi* on cuttings from Talstar-treated plants was significantly greater than those on control cuttings at 1, 7, 28, 35, and 42 DAT (two-sample *t*-test, $P < 0.05$). Bifenthrin is reported to produce a high immediate effect and a long impact on natural enemies when applied for insect control (5). The impact of bifenthrin and other insecticides on *Orius insidiousus*, another anthocorid, has been more extensively studied. Michaud and Grant (2003) compared three concentrations (label rate, 0.1×, and 0.01× label rate) against *O. insidiosus*. Mortality was 95.7 and 72.7% after 24 h exposure when exposed to label rate and 0.1× label rate, respectively (3). In our study, mortality of *M. moraguesi* on cuttings from bifenthrin-treated plants was >70% through 42 DAT.

Our results confirm that bifenthrin has an acute and long-term effect on this anthocorid which specifically attacks gall-inhabiting thrips. Products typically used for control of thrips (i.e., spinosad) that may be softer on beneficials are not effective against weeping fig thrips. Bifenthrin is the most effect insecticide against weeping fig thrips (2). As a result, bifenthrin cannot be used in concert with this biological control for control of weeping fig thrips in nurseries, landscapes, or interiorscapes. Two other biological controls, *Androthrips ramachandrai* and *Thripastichus gentilei*, also attack weeping fig thrips. There are no data on the impact of bifenthrin on these natural enemies. However, we predict similar impacts. At present, persons managing weeping fig thrips must choose between the efficacy of the chemical control or the sustainability of biological controls.

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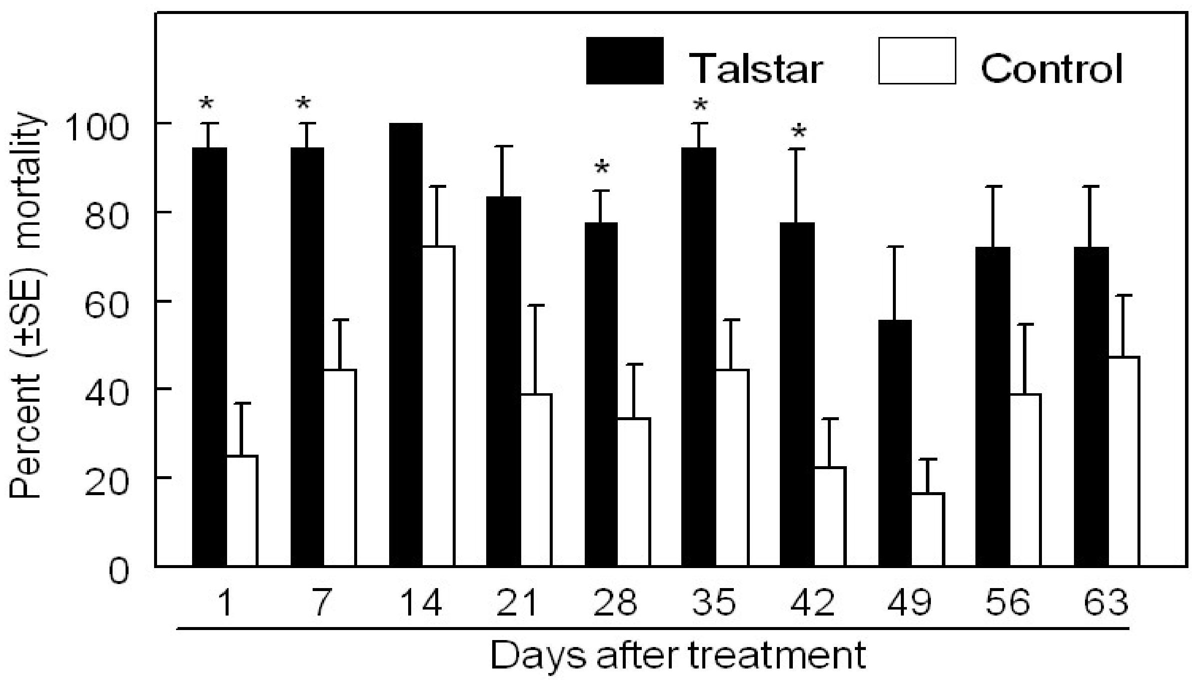

* denotes significant difference between treatment and control.