ENTOMOLOGY

Frank Hale
Section Editor and Moderator

Twenty-eight students competed In the Bryson L. James Student Research Competition and twenty-nine research projects were presented in poster form, which were displayed for review during the SNA Research Conference and Trade Show, this year. Their research is presented in the topical sections which follow and are designated as Student or Poster papers.

Evaluation of New Acaricides for the Management of Two-Spotted Spider Mites

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Nature of Work: Two-spotted spider mites have become an increasing problem in commercial ornamental production and landscape maintenance (1). These mites are the most frequently occurring pests on a wide variety of both woody and herbaceous ornamental plants. Several acaricides are currently registered for mite control. However, the management of mites has been increasingly more difficult in the past few years, indicating an increase in resistance to the current compounds (2). It is very important that we investigate new chemistries for their activity on mites, especially two-spotted spider mite.

Two experiments were conducted to evaluate new acaricides for the management of two-spotted spider mite in double poly greenhouses at the Griffin Experiment Station. Marigolds >Dwarf Bolero’ were infested with mites by placing infested leaves directly on plants in 4" pots. Treatments were applied with a high volume sprayer at 35 psi using a 8003 nozzle. Sampling was conducted by removing five leaves per plant (leaf consisting of seven terminal leaflets) and counting mites under the dissecting microscope. Post treatment population estimates were made 7, 14, 21, 28, and 35 days after application.

Results and Discussion: In the first experiment, Floramite™ and Pylon™ were compared to the standard acaricides, Avid™ and Sanmite™. Both standards provided quick knock down in the first week with excellent reduction in the mite population at two weeks (Table 1). Floramite and Pylon are new acaricides and also provided quick knock down in the first week. All treatments had a slight increase in mites on the fifth week indicating a decline in residual activity. Floramite was applied at two rates and both rates provided equal control for four weeks with an indication of a rate response at five weeks even though the means were not significantly different.

In a second experiment we tested two rates of a liquid drench of acephate (Orthene TTO™) to determine if we could obtain efficacy against mites (Table 2). A new formulation of acephate, Pinpoint™ , has been registered for container grown nursery stock. We have tested the Pinpoint formulation and that research indicated this formulation is effective in reducing two-spotted spider mite on ornamentals. However, there is a problem with phytotoxicity on some of the more tender herbaceous plants. Experiments have been conducted to look at reduced rates or other formulations. In this experiment, a common formulation of acephate was tested as a drench to check for reduced phytotoxicity. Orthene is commonly used as a foliar spray and does not provide efficacy for mites when applied in this way. However, it could have a different effect, similar to Pinpoint, if applied as a systemic to the potting media. Both rates of Orthene reduced mite populations but there was a rate response and the higher rate provided the most reduction. In a final evaluation for plant injury, phytotoxicity (15% injury level) was observed on plants receiving the high rate of Orthene drench. The low rate of Orthene did not have significant phytotoxicity but the reduction of mites was not acceptable. In addition, a new compound S-1283 (Valent USA) was tested for activity against two-spotted spider mite. S-1283 was effective as a miticide at week two (Table 2). Mite populations began to increase on week four. In this experiment the mite population was so excessive in the water control that the plants died of excessive mite damage at week 4. This accounts for the very low level of mites in the check.

Significance to Industry: Avid and Sanmite are still effective in reducing two-spotted spider mite under green house conditions. The new acaricides Floramite and Pylon provided excellent control for four weeks equal to or better than the two standards. Both compounds have been submitted for registration for use on ornamentals in greenhouses. They will provide alternatives to growers who are experiencing problems with resistance with the acaricides they are currently using. The drench of acephate gave reduction of mites at the higher rate but there was phytotoxicity in the more sensitive plants. Acephate granules or drench can be used, for reduction of mites, with plants were phytotoxicity is not a problem.

Table 1. Experiment 1 - Mean number of two-spotted spider mite per leaf.

Treatment	Rate per 100 gal	Precount	Week 1	Week 2	Week 3	Week 4	Week 5
Water Check		22.8b	71.3a	85.7a	85.2a	28.2a	76.0a
Avid 0.15 EC	4 oz	42.0a	1.7b	0.2b	1.8b	4.0b	8.4b
Sanmite 75WP	3 oz	10.5b	0.3b	0.0b	0.8b	0.5b	5.3b
Floramite WP	4 oz	16.2b	0.0b	0.3b	0.2b	0.8b	7.5b
Floramite WP	2 oz	9.7b	0.3b	0.0b	1.0b	2.2b	3.4b
Pylon	2.6 oz	10.5b	0.5b	0.7b	1.8b	2.2b	2.6b

Table 2. Experiment 2 - Mean number of two-spotted spider mite per leaf.

Treatment	Rate per 100 gal	Precount	Week 1	Week 2	Week 3	Week 4	Week 5
Check		7.8bc	106.3b	66.2a	123.8b	2.0b	0.0d
Avid	4 oz	35.6a	0.2e	0.2c	0.8c	50.8ab	13.8cd
S-1283 36EC	1 oz	7.5bc	7.3ed	2.0bc	1.6c	48.0ab	67.3abc
S-1283 36EC	0.5 oz	19.3ab	3.0	0.0c	5.5c	54.2ab	39.0bcd
S-1283 36EC	0.25 oz	15.7abc	8.5ed	1.2c	10.8c	79.3ab	111.8a
S-1283 80WP	0.5 oz	34.8a	22.0cde	5.8bc	9.7c	5.2b	43.4bcd
S-1283 80WP	0.12 oz	38.0a	27.2cde	9.2bc	43.0bc	16.0b	40.6bcd
Orthene TTO	8 oz	30.2ab	28.5cde	18.2bc	64.2bc	79.7ab	8.6cd
Orthene TTO	2 oz	18.0abc	59.7cde	63.3a	321.0a	122.7a	102.0ab

Literature Cited:

1. Hudson, W.G., S.K. Braman, R.D. Oetting, and B.L. Sparks. 1997. Ornamental, lawn and turf insects. In. Riley, D.G., G.K. Douce, and R.M. McPherson, Summary of Losses from Insect Damage and Costs of Control in Georgia 1996. GA Agric. Exper. Stn. Spec. publ. No. 91: 21-23.

2. Hudson, W.G., S.K. Braman, R.D. Oetting, and B.L. Sparks. 1996. Ornamental, lawn and turf insects. In. McPherson, R.M., G.K. Douce, and D.G. Riley, Summary of Losses from Insect Damage and Costs of Control in Georgia 1995. GA Agric. Exper. Stn. Spec. publ. No. 90: 20-22.

An Evaluation of Selected Miticides for control of Two Spotted Spider Mites, *Tetranychus urticae*, on Marigolds (*Tagetes erecta* 'Excel Primrose')

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Nature of Work: Two-spotted spider mites (*Tetranychus urticae*) are one of the most common and destructive arthropod pests encountered in the nursery and landscape industry. These tiny pests have a large host range, multiply very rapidly, and are notorious for developing miticide resistant populations. One of the strategies for combating pesticide resistance is by utilizing more than one chemical class (i.e., mode of action) in a pesticide spray rotation. (1). The purpose of this study was to determine the effectiveness of several miticides with the ultimate goal of helping growers make intelligent pesticide choices when determining mite control strategies.

Marigold plants, grown in the greenhouse at the Mobile Ornamental Horticulture Experiment Substation, were infested with two-spotted spider mites. Plants were infested by placing small (≈2 inch x 6 inch) sections of mite infested banana leaves on each plant. Two experiments were conducted testing a total of six distinct active ingredients and a combination of two active ingredients. For both experiments, 72 cell pack marigold liners were planted into trade gallon containers (Lerio C650) on March 23, 1998. Potting media consisted of a 3:1 (v:v) pine bark:peat moss mix amended with 6 lb dolomite limestone, 2 lb gypsum, 1.5 lb Micromax and 12 lb Osmocote 14-14-14 per cubic yard. Plants for experiment one were infested with mites on April 2 and for experiment two on April 12, 1998. Pre-treatment and miticide efficacy mite counts were performed using four preselected leaves containing at least one motile mite or (in the case of one plant) mite eggs. These four leaves were tagged by securing a twist-tie at the base of each petiole. Only the lower surface of the leaves were examined and only motile mites were counted. However, to insure that a majority of the mites on the preselected leaves were counted, both surfaces of the selected leaves were counted on 10 randomly selected plants at each sample date. Of the 78 mites counted on these 10 plants over the length of the study, only one mite was counted on the upper surface of the leaves. Mites were counted in the greenhouse with the aid of a 2.75x binocular magnifier. Both experiments were set up as a randomized complete block design using pretreatment counts and plant position on the greenhouse bench as blocking factors. Each experiment utilized six single plant replications of each treatment. The treatments for experiment one were as follows:

Treatment	Rate	Active Ingredient	Chemical Class
Untreated control			
Orthene TTO 75 SP drench	0.0013 oz/pot	acephate	organophosphate
Orthene TTO 75 SP drench	0.0026 oz/pot	acephate	organophosphate
Orthene TTO 75 SP drench	0.0053 oz/pot	acephate	organophosphate
Pinpoint 15G	0.026 oz/pot	acephate	organophosphate
Target Spray Oil	1 gal/100 gal	Petrolium oil	Horticultural oil
Hexygon	1.5 oz/100 gal	hexythiazox	thiazolidinone
Avid	4 fl oz./100 gal	abamectin	macrocyclic lactone
Hexygon/Avid tank mix.			
Hexygon	1.5 oz/100 gal	hexythiazox	thiazolidinone
Avid	4 fl oz/100 gal	abamectin	macrocyclic lactone

The treatments for experiment two were as follows:

Treatment	Rate	Active Ingredient	Chemical Class
Control			
American Cyanamid experimental	3 oz/100 gal	chlorfenapyr	pyrrole
compound (AC 303,630)			
Sanmite	3 oz/100 gal	pyridaben	pyridazinone

Plants in experiment one were treated on April 11, 1998; plants in experiment two were treated April 19, 1998. All spray treatments were sprayed until runoff using an R&D sprayer with a TVXS-6 conjet nozzle at 75-80 lb psi. A solution of Orthene TTO 75 SP was mixed so that each pot received its dose in 4 fl oz of water. The Pinpoint 15 G treatment was watered in with 4 fl oz of water per pot. Plants were not watered for over 24 hours following treatments.

Plants in experiment one were sampled for motile mites on 4/8-9, 4/17, 4/24, 5/1, 5/8, and 5/16, two to three days before treatment (DBT), 6, 13, 20, 27 and 35 days after treatment (DAT), respectively. Plants in experiment two were sampled for motile mites on 4/17-18, 4/24, 5/1, 5/8, and 5/16, one to two DBT, 5, 12, 19, and 27 DAT, respectively.

Data for both experiments were analyzed using ANOVA (Proc GLM, SAS). Means were separated using Duncan's Multiple Range Test. Acephate drench treatments in experiment one were further analyzed using trend analysis (Proc GLM, SAS) for linear, quadratic, and cubic trends. All data subsequent to the initial mite counts were transformed using a $\log_{10}(y+1)$ transformation before analyses.

Results and Discussion: Experiment I

Analyses demonstrated that there were no significant differences between treatments prior the start the experiment (Duncan's Multiple Range Test, $P \leq 0.05$) (Table 1). On the first sample date after treatment (6 DAT) only the 0.0013 and 0.0026 oz/pot Orthene TTO drenches were not significantly different (Duncan's Multiple Range Test, $P \leq 0.05$) from the untreated check (Table 1). Mite counts on sample dates 13-27 DAT showed significant differences between all treatments and the untreated check with 0.0026 and 0.0053 oz/pot Orthene TTO drenches, Pinpoint 15 G, Target Spray Oil, Hexygon, Avid and Hexygon/Avid tank mix having the lowest motile mite counts on each sample date (Table 1). By 35 DAT, mite populations from the untreated control plants appeared to be contaminating treated plants. This probably explains the observed increase in mites in treated plants and the fact that the hexygon treated plants were not significantly different from the 0.0013 oz/pot Orthene TTO treatment on that date. Trend analyses was performed on the Orthene TTO drench treatments and the untreated control. These analyses revealed a significant linear trend in the data for the 6 DAT sample date; significant linear and quadratic trends for the 13 DAT sample date and significant linear, quadratic and cubic trends for the 20, 27, and 35 DAT sample dates (Table 1).

On sample dates 5/8/98 and 5/16/98, 27 and 35 DAT respectively phytotoxicity was noted on treatments containing acephate (Orthene TTO 75 SP and Pinpoint 15 G) (2). Phytotoxic symptoms consisted of marginal necrosis.

Experiment II
Analyses demonstrated that there were no significant differences between treatments prior the start the experiment (Duncan's Multiple Range Test, $P \leq 0.05$) (Table 2). On all subsequent sample dates (5-27 DAT) all treatments were significantly different from the untreated check (Duncan's Multiple Range Test, *P*£ 0.05) (Table 2).

Significance to Industry: The results of these tests indicate that growers have several excellent and unique miticides to place into their mite management programs. The use of two or more of these materials in a miticide rotation should help prevent or delay a miticide resistance problem.

Testing a few plants for phytotoxicity prior the widespread use of these or any unfamiliar pesticide is advisable, especially when the treated crop is not specified on the label. Always read and follow label instructions before using any pesticide.

Acknowledgement: This research was made possible through support from Valent U.S.A., Inc. and the Alabama Agricultural Experiment Station.

Literature Cited:

1. Marer, P.J., M.L. Flint, and M. W. Stimmann. 1988. The Safe and Effective Use of Pesticides. University of California DANR Publication 3324. Oakland, CA. 387 pp.

2. Hesselein, C.P., J.R. Chamberlin and M.L. Williams. 1998. Evaluating Orthene TTO 75 SP Drenches and Pinpoint 15G Formulations for Phytotoxicity to Selected Herbaceous Ornamental Plants. Proceedings of the 1998 SNA Research Conference. (In press).

Table 1 Experiment I, Number of Motile Mites Counted on Days Before Treatment (DBT) or Days After Treatment (DAT)

Treatment	Rate	2 DBT	6 DAT	13 DAT	20 DAT	27 DAT	35 DAT
Untreated control		2.0 a[z]	12.5 a *	24.8 a *, **	46.0 a *, **, ***	110.8 a *, **, ***	221.2 a *, **, ***
Orthene TTO 75 SP drench	0.0013 oz/pot	2.2 a	11.0 a *	2.3 b *, **	2.7 b *, **, ***	3.2 b *, **, ***	5.0 b *, **, ***
Orthene TTO 75 SP drench	0.0026 oz/pot	2.5 a	9.2 ab *	0.2 c *, **	0.8 c *, **, ***	0.2 c *, **, ***	1.3 c *, **, ***
Orthene TTO 75 SP drench	0.0053 oz/pot	2.5 a	3.2 b *	0.0 c *, **	0.0 c *, **, ***	0.0 c *, **, ***	0.7 c *, **, ***
Pinpoint 15G	0.026 oz/pot	2.7 a	3.8 b	0.2 c	0.0 c	0.0 c	0.7 c
Target Spray Oil	1 gal/100 gal	2.5 a	0.0 c	0.7 c	2.3 c	0.0 c	0.3 c
Hexygon	1.5 oz/100 gal	2.5 a	0.0 c	0.0 c	0.0 c	0.0 c	4.3 bc
Avid	4 fl. oz./100 gal	2.7 a	0.0 c	0.0 c	0.0 c	0.0 c	1.7 c
Hexygon/Avid tank mix. Hexygon Avid	 1.5 oz/100 gal 4 fl oz/100 gal	2.3 a	0.0 c	0.0 c	0.0 c	0.0 c	2.2 c

[z]Data analyzed using Proc GLM in SAS means separated using Duncan's Multiple Range Test. Means followed by the same letter not significantly different at P 0.05. All data except initial counts (DBT) performed on data transformed using log10(y+1). Untransformed data are presented.

*, **, *** Trend Analysis significant ($P \leq 0.05$) for linear, quadratic and cubic response trends respectively.

Table 2 Experiment II, Number of Motile Mites Counted on Days Before Treatment (DBT) or Days After Treatment (DAT)

Treatment	Rate	1 DBT	5 DAT	12 DAT	19 DAT	27 DAT
Untreated control		4.7 a[z]	6.7 a	21.0 a	61.3 a	167.3 a
American Cyanamid experimental compound (AC 303,630)	3 oz/100 gal	7.3 a	0.0 b	0.0 b	0.0 b	1.8 b
Sanmite	3 oz/100 gal	5.7 a	0.2 b	0.0 b	0.0 b	1.3 b

[z]Data analyzed using Proc GLM in SAS, means separated using Duncan's Multiple Range Test. Means followed by the same letter not significantly different at P 0.05. All data except initial counts (DBT) performed on data transformed using $log_{10}(y+1)$. Untransformed data are presented.

Evaluating Orthene TTO 75 SP Drenches and Pinpoint 15G Formulations for Phytotoxicity to Selected Herbaceous Ornamental Plants

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Nature of Work: Phytotoxicity trials were performed on eighteen herbaceous species: 'Excel Primrose' marigold (*Tagetes erecta* 'Excel Primrose'), buddleia (unknown white cultivar) (*Buddleia davidii*), 'Saturn Mix' geranium (*Pelargonium* x *hortorum* 'Saturn mix'), 'Nagoya red' kale (*Brassica oleracea* 'Nagoya red'), 'Tahiti Lilac Bicolor' snapdragon (*Anthirrhinum majus* 'Tahiti lilac bicolor'), *Aglaonema* sp. 'Silver King', 'Tropicana White' vinca (*Catharanthus rosea*. 'Tropicana White'), hibiscus (*Hibiscus rosa-sinensis* unknown red cultivar), 'Asterisk' ivy (*Hedera helix* 'Asterisk'), 'Scottsdale' garden mum (*Dendranthma morifolia* 'Scottsdale'), gerbera daisy (G*erbera jamesonii* unknown yellow cultivar), 'Freckles' sun coleus (*Coleus* x *hybridus* 'Freckles'), lemon balm (*Melissa officinalis*), 'Rasberry Ice' bougainvillea (*Bougainvillea* x *hybrida* 'Rasberry Ice'), 'Dream Purple' petunia (*Petunia* x *hybrida* 'Dream Purple'), 'Perfection Mix' marigold (*Tagetes erecta* 'Perfection Mix'), 'Peterstar Marble' poinsettia (*Euphorbia pulcherrima* 'Peterstar Marble'), and Croton (*Codiaeum variegatum pictum*). All plants were grown in trade gallon containers using a 3:1 v:v pine bark:peat moss medium amended with 6 lb dolomite limestone, 2 lb gypsum and 1.5 lb micromax per cubic yard.

Hibiscus, ivy, garden mum, gerbera daisy, sun coleus, lemon balm, bougainvillea, petunia, 'perfection mix' marigold, poinsettia, and croton were treated according the treatments listed in Table 4. Kale was treated using the treatments listed in Table 1. Aglaonema, vinca, snapdragons, geraniums, and buddleia were treated according to treatments listed in Tables 6&7. 'Excel Primrose' marigolds were treated according to treatments listed in Table 3.

SunSpray UFSO treatments were sprayed until runoff using an R&D sprayer with a TVXS-6 conjet nozzle at 40 lb psi ('Excel Primrose' marigolds were sprayed at 75-80 lb psi).

All plants were well established in their pots (*i.e.,* root growth observed at container-media interface) and were grown in full sun in the field or in a shaded greenhouse (Table 2). Plants were hand watered, drip irrigated or watered with overhead impact irrigation (Table 2).

Plants were rated for severity of phytotoxicity using a 1-12 rating scale developed by Horsfall and Barratt where 1= 0 percent, 2= 0-3 percent, 3= 3-6 percent, 4= 6-12 percent, 5= 12-25 percent, 6= 25-50 percent, 7= 50-75 percent, 8= 75-88 percent, 9= 88-94 percent, 10= 94-97 percent, 11= 97-100 percent and 12= 100 percent phytotoxicity. Data were analyzed using ANOVA (Proc GLM, SAS). When F values were significant ($P \leq 0.05$) treatment means were separated using Duncan's Multiple Range Test ($P \leq 0.05$).

Results and Discussion: Phytotoxicity was observed on poinsettia (Table 3), petunia (Table 4), kale, snapdragon, 'Excel Primrose' marigold (Table 5), buddleia (Table 6), geranium (Table 7) and possibly vinca. SunSpray UFSO removed the waxy coating on the leaves of kale (observations only, not rated) and caused foliar bronzing and premature flower senescence in snapdragons (data not presented). Foliar marginal and interveinal chlorosis and/or necrosis caused by Orthene TTO 75 SP (OTTO) drenches and Pinpoint 15 G treatments were observed in poinsettia (Table 3), petunia (Table 4), 'Excel Primrose' marigold (Table 5), buddleia (Table 6), geranium (Table 7), and possibly vinca. Vinca plants were sunburned when moved from a protected greenhouse into full sun. The sunburn damage made visual ratings an unreliable method of quantifying treatment related phytotoxicity. However, observations of the vinca plants indicated that some of the marginal necrosis was treatment related (0.035 oz Pinpoint and 0.007 oz OTTO treatments). Damage due to OTTO drenches and Pinpoint 15 G treatments was first observed as early as 3 days after treatment (DAT) on petunia and as late as 27 DAT on 'Excel Primrose' marigold. For petunia, damaged foliage was observed only at 3 DAT; by 10 DAT new growth covered the previously observed damage and no additional phytotoxicity was observed. Damage observed on untreated control plants on the final observation date (35 DAT) for 'Excel Primrose' marigold was most likely caused by two-spotted spider mite feeding (1). For poinsettia, 'Excel Primrose' marigold, buddleia, and geranium phytotoxicity caused by OTTO and Pinpoint treatments was noted on all observation dates subsequent to initial phytotoxicity observation.

Significance to Industry: Orthene TTO 75 SP, Pinpoint 15 G and horticultural oils (e.g., Target Oil, SunSpray Ultra Fine Spray Oil) are commonly used and broadly effective pesticides. A major impediment to the expanded use of these materials in pest management programs is their potential phytotoxicity. Of the eighteen taxa tested, seven ('Peterstar Marble' poinsettia, 'Dream Purple' petunia, 'Nagoya Red' kale, 'Tahiti Lilac Bicolor' snapdragon, 'Excel Primrose' marigold, white buddleia and 'Saturn Mix' geranium) demonstrated unmistakable symptoms of phytotoxicity to one or more of the treatments. This study demonstrates the importance of testing a few plants prior the widespread use of these or any unfamiliar pesticide, especially when the treated crop is not specified on the label. Always read and follow label instructions before using any pesticide.

Acknowledgement: This research was made possible through support from Valent U.S.A., Inc. and the Alabama Agricultural Experiment Station.

Literature Cited:

1. Hesselein, C.P., J.R. Chamberlin and M.L. Williams. 1998. An Evaluation of Selected Miticides for control of Two Spotted Spider Mites, *Tetranychus urticae*, on Marigolds (*Tagetes erecta* 'Excel Primrose'). Proceedings of the 1998 SNA Research Conference. (In press).

Table 1. Treatments used for 'Nagoya Red' kale

Treatment	Rate
Untreated Control	
Orthene TTO 75 SP drench[w]	0.0009 oz/pot
Orthene TTO 75 SP drench[w]	0.0018 oz/pot
Orthene TTO 75 SP drench[w]	0.007 oz/pot
Pinpoint 15G[w]	0.018 oz/pot
Pinpoint 15G[w]	0.035 oz/pot
SunSpray UFSO	1 gal/100 gal

w Orthene TTO 75 SP drenches and Pinpoint 15 G treatments applied with or watered in with 3.4 fl oz water

Table 2. Cultural practices used in study

Plant	Plant Date	Treatment Date	Irrigation Method	Growing Conditions
Buddleia	1997	4/22/98	Hand watered, as needed	Greenhouse
Vinca	Fall 1997	4/22/98	Daily overhead impact irrigation	Full Sun
Geranium	Winter 1998	4/22/98	Hand watered, as needed	Greenhouse
Marigold 'Perfection Mix'	9/5/97	4/11/98	Drip irrigated as needed	Greenhouse
Snapdragon	Fall 1997	2/23/98	Overhead impact irrigation, as needed	Field, in full sun
Aglaonema	9/12/97	2/23/98	Hand watered, as needed	Greenhouse
Kale	Summer 97	10/24/97	Overhead impact irrigation, as needed	Field, in full sun
Coleus	8/7/97	8/22/97	Daily overhead impact	Field, in full sun
Gerbera	8/15/97	8/22/97	Daily overhead impact	Field, in full sun
Garden Mum	7/24/97	8/22/97	Daily overhead impact	Field, in full sun
Ivy	8/7/97	10/3/97	Hand watered as needed	Greenhouse
Croton	8/7/97	9/19/97	Hand watered as needed	Greenhouse
Lemon Balm	8/18/97	9/19/97	Daily overhead impact	Field, in full sun
Bougainvillea	9/5/97	10/3/97	Hand watered as needed	Greenhouse
Petunia	9/5/97	9/19/97	Daily overhead impact	Field, in full sun
Marigold 'Excel Primrose'	3/23/98	9/19/97	Daily overhead impact	Field, in full sun
Poinsettia	9/12/97	10/3/97	Hand watered as needed	Greenhouse
Hibiscus	9/12/97	10/3/97	Hand watered as needed	Greenhouse

Table 3. Phytotoxicity observations of leaf tip and margin necrosis for 'Peterstar Marble' poinsettia using 12 point Horsfall-Barratt rating scale

'Peterstar Marble' poinsettia		Initial Phyto Rating (14 DAT)	Date (DAT) of greatest phyto (rating)	Rating at Conclusion (43 DAT)
Untreated Control		1.8e[y]	28 DAT (2.8)	1.0d
Orthene TTO 75 SP drench[x]	0.0009 oz/pot	3.2d	43 DAT (5.5)	5.5c
Orthene TTO 75 SP drench[x]	0.0018 oz/pot	5.4c	43 DAT (7.6)	7.6b
Orthene TTO 75 SP drench[x]	0.0035 oz/pot	6.7b	43 DAT (8.7)	8.7a
Pinpoint 15G[x]	0.018 oz/pot	5.0c	43 DAT (7.2)	7.2b
Pinpoint 15G[x]	0.035 oz/pot	8.8a	21 DAT (10.7)	9.2a

[y] Means followed by same letter are not significantly different (Duncan's Multiple Range Test $P \leq 0.05$)

[x] Orthene TTO 75 SP drenches and Pinpoint 15 G treatments applied with or watered in with 4 fl oz water

Table 4. Phytotoxicity observations of interveinal leaf chlorosis and necrosis for 'Dream Purple' petunia using 12 point Horsfall-Barratt rating scale

'Dream Purple' petunia		Initial Phyto Rating (3 DAT)	Date (3 DAT) of greatest phyto (rating)	Rating at Conclusion (28 DAT)
Untreated Control		1.0a[y]	1.0a	NA
Orthene TTO 75 SP drench[x]	0.0009 oz/pot	1.0a	1.0a	NA
Orthene TTO 75 SP drench[x]	0.0018 oz/pot	1.0a	1.0a	NA
Orthene TTO 75 SP drench[x]	0.0035 oz/pot	1.0a	1.0a	NA
Pinpoint 15G[x]	0.018 oz/pot	1.0a	1.0a	NA
Pinpoint 15G[x]	0.035 oz/pot	2.5b	2.5b	NA

[y] Means followed by same letter are not significantly different (Duncan's Multiple Range Test $P \leq 0.05$)

[x] Orthene TTO 75 SP drenches and Pinpoint 15 G treatments applied with or watered in with 4 fl oz water

Table 5. Phytotoxicity observations of marginal leaf chlorosis and necrosis for 'Excel Primrose' marigold using 12 point Horsfall-Barrat rating scale

'Excel Primrose' marigold		Initial Phyto Rating (27 DAT)	Date (DAT) of greatest phyto (rating)	Rating at Conclusion (34 DAT)
Untreated Control		3.7cd[y]	34 DAT (6.7)	6.7a
Orthene TTO 75 SP drench[x]	0.0013 oz/pot	4.7c	27 DAT (4.7)	4b
Orthene TTO 75 SP drench[x]	0.0026 oz/pot	6.2b	27 DAT (6.2)	5.8a
Orthene TTO 75 SP drench[x]	0.0053 oz/pot	7.5a	27 DAT (7.5)	7a
Pinpoint 15G[x]	0.026 oz/pot	6b	27 DAT (6)	6a
Target Insecticidal Oil	1 gal/100 gal	4cd	27 DAT (4)	1.7c
Hexygon	1.5 oz/100 gal	3.8cd	27 DAT (3.8)	2c
Avid	4 fl. oz./100 gal	3.7cd	27 DAT (3.7)	2.5bc
Hexygon/Avid tank mix. Hexygon Avid	 1.5 oz/100 gal 4 fl oz/100 gal	3.3d	27 DAT (3.3)	1.5c

[y] Means followed by same letter are not significantly different (Duncan's Multiple Range Test $P \leq 0.05$)

[x] Orthene TTO 75 SP drenches and Pinpoint 15 G treatments applied with or watered in with 4 fl oz water

Table 6. Phytotoxicity observations of leaf tip + marginal necrosis for white buddleia using 12 point Horsfall-Barratt rating scale

Buddleia (unknown white cultivar)	Rate	Initial Phyto Rating[z] (14 DAT)	Date (36 DAT) of greatest phyto (rating)	Rating at Conclusion (36 DAT)
Untreated Control		1.8c[y]	5.2c	5.2c
Orthene TTO 75 SP drench[w]	0.0018 oz/pot	5.0b	15.0b	15.0b
Orthene TTO 75 SP drench[w]	0.004 oz/pot	5.8ab	17.2ab	17.2ab
Orthene TTO 75 SP drench[w]	0.007 oz/pot	7.2a	21.8a	21.8a
Pinpoint 15G[w]	0.018 oz/pot	4.8b	14.2b	14.2b
Pinpoint 15G[w]	0.035 oz/pot	5.8ab	17.2ab	17.2ab
SunSpray USFO	1 gal/100 gal	1.8c	5.2c	5.2c

[z] Ratings are a combination of separate rating observations for leaf tip damage and leaf margin damage. Only leaf tip damage was noted on initial phytotoxicity rating date (14 DAT).

[y] Means followed by same letter are not significantly different (Duncan's Multiple Range Test $P \leq 0.05$)

[w] Orthene TTO 75 SP drenches and Pinpoint 15 G treatments applied with or watered in with 3.4 fl oz water

Table 7. Phytotoxicity observations of marginal leaf necrosis for 'Saturn mix' geranium using 12 point Horsfall-Barratt rating scale

Untreated Control	Rate	Initial Phyto Rating (14 DAT)	Date (DAT) of greatest phyto (rating)	Rating at Conclusion (36 DAT)
Untreated check		1.0c[y]	21 DAT (1.8)	1.6c
Orthene TTO 75 SP drench[w]	0.0018 oz/pot	3.0b	28 DAT (5.0)	4.2b
Orthene TTO 75 SP drench[w]	0.004 oz/pot	6.0a	21 DAT (6.6)	5.2a
Orthene TTO 75 SP drench[w]	0.007 oz/pot	7.0a	14 DAT (7.0)	5.4a
Pinpoint 15G[w]	0.018 oz/pot	2.0bc	28 DAT (5.4)	4.6ab
Pinpoint 15G[w]	0.035 oz/pot	2.6b	21 & 28 DAT (6.0)	5.2a
SunSpray USFO	1 gal/100 gal	1.0c	28 DAT (2.0)	1.0c

[y] Means followed by same letter are not significantly different (Duncan's Multiple Range Test $P \leq 0.05$)

[w] Orthene TTO 75 SP drenches and Pinpoint 15 G treatments applied with or watered in with 3.4 fl oz water

IR-4 Research For Pest Control in Nursery Crops- 1997

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Nature of Work: Efficacy and phytotoxicity research trials are needed for use in obtaining national label registrations for pesticides and biopesticides. During 1997, research was needed for 28 fungicides, 28 herbicides, 27 insecticides and 6 plant growth regulators. The research conducted included pesticide evaluations for nursery, floral, forestry and Christmas tree production. Research conducted in 1997 also included pesticide trials to develop data for national registrations for the commercial landscape, interior plantscapes and tissue culture production.

Protocols were developed to insure uniformity and accuracy of the data needed for national label registrations. In 1997 research was conducted by 28 state, federal, and private researchers in 15 states in 432 separate funded trials. There were 107 trials conducted gratis.

Results and Discussion: During 1997, data were collected for these 9 fungicides:

•*Ampelomyces quisqualis* (AQ-10 Biofungicide)
•Bordeaux mixture (13.3%)
•chlorothalonil (Daconil Ultrex 82.5%)
•etridazole (Ethazole) (Truban 5G)
•flutolanil (Prostar 50 WP)
•fosetyl-Al (Chipco Aliette WDG 80)
•Physan 20
•tebuconazole (Lynx 25)
•thiophanate methyl (Clearys 3336 4.5F)

Fourteen herbicides were also evaluated during 1997 including:

•bentazon (Basagran T/O)
•clethodim (Envoy 12.6%)
•2,4-D LV Ester (Weedone LV4)
•dithiopyr (Dimension 1EC)
•diuron (Direx 80 DF)
•halosulfuron (Permit)
•isoxaben (Gallery 75DF)
•napropamide
(Devrinol 5G or Devrinol 50DF)
•Oryzalin (Surflan AS 40.4%, XL 2G)
•oxadiazon (Chipco Ronstar G or
Chipco Ronstar 50 WP)
•oxyfluorfen (Goal T/O 2XL)
•oxyfluorfen +oryzalin (Rout 2G)
•pendimethalin (Pendulum
•60 WDG, Ornamental Weed Grass
Control G 2.8%)
•napropamide prodiamine
(Barricade 65 WG, Factor 65)

Research was also conducted on 14 insecticides including:

•acephate (Orthene Turf, Tree and Ornamental Spray)
•bendiocarb (Dycarb 76WP, Turcam 2.5G, Turcam76)
•bifenthrin (Talstar Nursery Flowable, Talstar Nursery Granular)
•capsaicin (Champons 100% Natural)
•chlorpyrifos (Dursban 50 W, 4EN)
•diazinon (Knox Out 2FM)
•fenitrothion (Pestroy 4EC)
•formetanate hydrochloride (Carzol SP)
•hexythiazox (Hexagon, Savey 50WP)
•horticulture oil (Sun Spray Ultra-Fine Spray Oil)
•malathion (Malathion 5EC, Gowan Malathion 8)
•pirimicarb (Pirimor 50 DF)
•pyridaben (Sanmite 75)
•trichlorfon (Dylox 80)

Trials with the plant growth regulator ethephon (Florel) were also conducted.

During 1997, 154 Ornamental uses were registered for use in the nursery and floral crop industry (Table 1).

Significance to Industry: The IR-4 Ornamental research program has developed data for over 5000 label registrations for the green industry.

Literature Cited:

1. IR-4 1993. Project Statement. October 1, 1993- September 30, 1998. NJAES, Cook College, Rutgers University, New Brunswick, NJ. 37pp

2. IR-4 1997. Annual Report. NJAES, Cook College, Rutgers University, New Brunswick, NJ. 53pp

3. IR-4 1998. Commercially Grown Floral, Forestry, Nursery and Turf Crops, IR-4 Minor Use Report Card- 1998 Update. 15pp

4. Quality Assurance: Good Practice, Regulation, and Law Vol. 3, No. 3, September, pp. 254-266, 1994

Table 1. 1997 Pesticide Registrations supported by IR-4 Data

bendiocarb (Turcam 2.5G 76, Dycarb 76WP)
- Andromeda (Pieris)
- Apple (non-bearing)
- Arborvitae
- Azalea
- Crabapple
- Geranium
- Juniper
- Privet
- Rhododendron

chlormequat chloride (Cycocel 11.8%)
- Columbine
- False Spirea
- Geranium
- Hibiscus

chlorothalonil (Daconil 2787)
- Aster
- Baby's Breath
- Balsam
- Cactus
- Croton
- Flowering Dogwood
- Good Luck Plant, Ti Plant
- Jade Plant
- Pine, Air
- Pine, Norfolk Island
- Plum (non-bearing)
- Redwood

clethodim (Envoy)
- Daylily
- Stonecrop
- Sedum X spectabile

Daminozide (B-Nine)
- Larkspur

DCPA (Dacthal)
- Kentucky Blue Grass

diquat dibromide (Reward)
- Easter Lily

dithiopyr (Dimension 1EC)
- Geranium
- Hawthorn
- Juniper
- Sugar Maple
- Red Oak

fluazifop-butyl (Fusilade TO Herbicide)
- Ajuga
- Ice plant

fosetyl-Al (Chipco Aliette WDG)
- Azalea
- Rose

isofenphos (Oftanol 2)
- Andromeda (Pieris)
- Arborvitae
- Ash

Azalea
- Birch
- Crabapple (non-bearing)
- Geranium
- Hemlock
- Japanese Holly
- Japanese Maple
- Juniper
- Kentucky Bluegrass
- Laurel (Kalmia)
- Linden
- Black Locust
- Maple
- Oak
- Plane Tree
- Privet
- Rhododendron
- Yellowwood
- Yew

isoxaben (Gallery 75DF)
- Flowering Dogwood
- Fosters Holly
- Holly

Malathion(Malathion 5EC, Gowan Malathion)
- Chrysanthemum

mancozeb (Penncozeb 75DF Protect T & O)
- Gloxinia

methiocarb (Mesurol 75-W)
- Afican Violet
- Chrysanthemum

oxydemeton-methyl (Metasystox-R)
- Spruce

oxytetracycline(Mycoject 4.2%)
- Pear (non-bearing)

paraquat (Gramoxone Extra)
- Easter Lily

PCNB (Terraclor 75 WP,400)
- Pansy
- Snapdragon

horticulture oil (Sun Spray Ultra-Fine Spray Oil)
- Ageratum
- Ash
- Azalea
- Balsam
- Camellia
- Carnation
- Cocunut Palm
- Crown of Thorns
- Hydrangea
- Leatherleaf Fig
- Maidenhair Fern
- Marigold
- Moth Orchid
- Petunia
- Philodendron
- Rose
- Shasta Daisy
- Transvaal Daisy
- Zinnia

Table 1 continued

triadimefon (Bayleton 25, 50, Strike 25WDG)
- Purple Wintercreeper

Trifluralin (TreflanE.C,5G, Gowan Trifluralin E.C.,10G)
- Bellflower
- Cone Flower
- Pincushion Flower
- Sage
- Speedwell

vinclozolin (Curalan D.F., E.G., Ornalin FL)
- Balsam
- Begonia
- Carnation
- Cherry (non-bearing)
- Chrysanthemum
- English Ivy
- Geranium
- Hydrangea
- Madwort
- Marigold
- Petunia
- Plum (non-bearing)
- Poinsettia
- Snapdragon
- Zinnia

Biological Control Approaches for Southern Nursery and Greenhouse Growers

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Nature of Work: Greenhouse and nursery growers have long awaited the opportunity to shift their insect and mite management practices from a complete reliance on conventional insecticides to more diverse or integrated strategies. Opportunities for integrated strategies have arisen due to the increasing availability of parasitoids and predators, recent developments of environmentally benign botanical insecticides and insect growth regulators, commercial propagation of plant varieties with elevated resistance to insect attacks, and development of a number of cultural techniques such as exclusion devices. Biological control has also added a new look due to recent work addressing better ways to release natural enemies and due to the recent expansion of commercially available, disease-causing pathogens of greenhouse and nursery pests. I will discuss these advances using aphids as a model system.

Aphids are significant and frequently insecticide resistant pests of cut and potted floricultural and nursery crops worldwide. Aphid damage to these crops is caused by direct feeding, which results in wilting, leaf distortion, and transmission of several viruses, and indirect cosmetic damage from cast skins and honeydew production. Greenhouses provide an optimal environment for explosive aphid population growth. Aphid young are born fully formed and are able to feed immediately. They grow rapidly, and because normal sexual reproduction is not required, eggs can start developing within an aphid when or before it is born. By the time a female matures, several young are fully developed in her reproductive system and are ready to be born at a rate of 3 to 6 a day for several weeks.

In response to this problem, and with generous support from the American Floral Endowment, Yoder Brothers Inc., Novartis BCM North America, Mycotech Corporation, and Troy Biosciences Inc., my laboratory has been studying methods for using commercially available natural enemies for biological aphid control in an economical and reliable manner. We have been concentrating our effort on the aphid parasitoid *Aphidius colemani*, the predatory green lacewing *Chrysoperla rufilabris*, and the fungal pathogen Beauvaria bassiana.

***Beauvaria bassiana* Studies**. Whether the Mycotech Corp. (BotaniGard®) and/or Troy Biosciences Inc. (Naturalis-O®) formulations of *Beauvaria bassiana* provide effective forms of microbial aphid control, and whether their application rates significantly effect aphid efficacy were tested in commercial greenhouse facilities located in east Texas. Blocks of 324 potted chrysanthemums, each initially inoculated with 2 green peach aphids per plant, were treated weekly with one rate of BotaniGard ES (0.32 oz / gal water), three rates of Naturalis O- (1.00 oz, 0.66 oz, and 0.30 oz per gal water) and a water blank. Ounce for ounce, BotaniGard ES contains 1000-times more spores of *B. bassiana* than the Naturalis-O formulation. Trials were conducted for 5 weeks during which aphid densities were censused weekly.

Results and Discussion: Weekly applications of Naturalis-O (at 1 oz / gal) and BotaniGard ES (at 0.3 oz / gal) provided the greatest levels (89 - 86% suppression relative to the water blank) of aphid control. Increasing the dose of *B. bassiana* increased the subsequent level of aphid control: control was greatest at the highest dosage of Naturalis-O (6.9 10^7 spores per treated block), moderate at the intermediate dosage (4.5 10^7 spores per treated block), and the least at the lowest dosage (2.1 107 spores per treated block). Application of *B. bassiana* spores utilizes conventional spray equipment, can provide satisfactory control of aphids, and hence could be implemented as part of an IPM program.

***Chrysoperla* and *Aphidius* Studies.** During the early stages of an outbreak, aphids form small clumps on individual plants within chrysanthemum greenhouses. These initial outbreaks quickly become serious problems because aphid populations quadruple in size daily when occurring on healthy plants. In addition, results conducted by Dr. Heinz's laboratory in Texas A&M University greenhouses demonstrated that green peach aphids can spread over an area of 120 ft^2 per day after infesting an single potted chrysanthemum. Hence, aphids may be present for a long period of time within a greenhouse and have the opportunity to reproduce and spread throughout the crop before being noticed. With respect to using predators and parasitoids for successful aphid biological, these natural enemies must locate and consume aphid patches when they are relatively scarce and before the aphids infest the entire greenhouse. Therefore, growers should only use the most effective predators and parasitoids, and release them in such a manner whereby they can locate and kill aphids at a sufficiently high rate.

Results and Discussion: Determining exactly how natural enemies respond to aphid patches as they change in time and space requires long and tedious experiments. After completing a set of intensive studies, Dr. Heinz's laboratory discovered the limitations to obtaining biological aphid control by releasing predators and parasitoids. Green lacewing larvae, used as a model predator, were found to be incapable of navigating between potted chrysanthmums placed atop solid benches. Although lacewing larvae voraciously consume aphids once discovered, successful biological control requires placement of lacewing larvae onto each individual plant infested with aphids.

By comparison, studies with the wasp *A. colemani* demonstrated that it could spread over an area of 147 ft^2 per day after being released from a single potted chrysanthemum. From these results, the Heinz lab determined that the most effective biological aphid control could be obtained by releasing *A. colemani* from points no greater than 12 feet apart within a potted chrysanthemum greenhouse.

Greenhouse trials were conducted to test the influence of *A. colemani* release strategies on their ability to biologically control green peach aphids in research greenhouses. Wasps were released at the rate of three per pot per week from 4 points, 12 feet apart or from one central point within 1200 ft2 greenhouses filled with potted chrysanthemums. Additionally, each greenhouse contained a screened cage, which covered a bench of chrysanthemums, and prevented wasps from accessing aphid infested plants. Comparisons between aphids densities within the cages to those outside the cages (into which *A. colemani* were released) provided an experimental method for assessing the impact of parasitoid releases. At the beginning of the trial, every third pot within the greenhouse was infested with three green peach aphids.
Both *A. colemani* treatments (released from 1 or from 4 points) yielded significant suppression of green peach aphids. Densities in the cages from which wasps were excluded exceeded 5,000 aphids per plant by week 6 of the trials. Aphid densities climbed to 27.5 per plant at week 10 in greenhouses where wasps were released from one central point. By comparison, aphid densities reached a maximum of 5.8 per plant at week 3 in greenhouses where wasps were released from four points.

The quality of the potted chrysanthemums harvested at the completion of each trial were determined by 14 horticulture and entomology faculty, staff, and student who judged a representative sample of pots from each treatment. Because plants were not pinched, grown under shade cloth, or treated with growth regulators quality, estimates probably represent a minimum for each treatment.

Pots from the aphid infested cages were judged completely unacceptable, always ranking the poorest in quality and never being acceptable for purchase as a gift. Pots from greenhouses where wasps were released from four sites always ranked higher in quality than pots from greenhouses where wasps were released from a single location. Further, the percentages of pots deemed acceptable for gift-giving from the 4-release point greenhouses were greater than the percentages of gift quality pots never infested with aphids. Thus, biological control is not only an effect method of aphid control, but facilitates production of high quality potted chrysanthemums.

Significance to Industry: The fungal pathogen *B. bassiana* provides grower with biological control method for controlling aphid that utilizes traditional application technologies with which growers are well acquainted. In addition, recent studies aimed at developing guidelines for efficient releases of aphid parasitoids provides growers with second effective strategy for biological aphid control. Future studies are planned for testing these biological control programs within the context of commercial crop production and for completion of economic assessments of each approach. Economic assessments conducted on the results reported here suggest these biological-control based methods of pest management will be competitively priced to traditional chemical approaches.

Acknowledgement: The above research was funded by the American Floral Endowment and Yoder Bros. (aphids), and by Mycotech Corp. and Troy Biosciences (*B. bassiana*).

An Evaluation of New Insecticides for the Control of a Maple Shoot Borer, Proteoteras aesculana Riley (Lepidoptera: Tortricidae) in Seedling Red Maple

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Nature of Work: A shoot boring caterpillar, *Proteoteras aesculana* Riley, is an important pest of red maples in Tennessee nurseries. Past studies have determined the proper timing of chemical pest control and the most efficacious insecticides (1,2,3). This test was designed to compare the efficacy of two new insecticides with that of Talstar T & O 10WP which has been the most efficacious insecticide previously tested (1,2,3).

A block of seedling red maple at the Bob Young Nursery in Warren County, Tennessee, was selected for the test. The distance between rows averaged 5.0 feet. The trees had an average height of 3.85 feet and this was the second growing season in the field. The tree phenology on May 5, 1998 for 9.1 percent of the trees ranged from tight bud to 1/2 inch green, 1.4 percent had one pair of leaves, 29.7 percent had two pair of leaves, 48.0 percent had three pair of leaves and 11.8 percent had four to five pair of leaves. It has been our experience (1,2,3) that it is best to use a foliar insecticide spray when the first two pair of leaves have come out. Seedling red maple tend to have a greater range of phenology than cultivars used in past studies (1,2,3). For this reason, the foliar spray treatment date of the present study of May 5 was later than the treatment dates of previous studies of April 20 (1), April 2 (2) and April 24 (3).

Due to the greater range of phenology of the seedling red maple, there was already some damage detected prior to treatment. Trees with damage were flagged just prior to treatment so that they would not be counted as part of the treatments when damage ratings were made. The insecticides applied as foliar sprays on May 5 were Talstar T & O 10%WP (0.96 oz/10 gal), Conserve SC Turf and Ornamental 11.6% suspension concentrate (6 fl oz/100 gal.) and Confirm 2 F (8 oz/acre) plus Latron CS-7 surfactant (8 oz/acre). While Talstar T & O and Conserve SC are both labeled for use on ornamentals, Confirm 2F is currently labeled for use on walnuts. The sprays were applied at a 25 gal/acre rate using a CO2 compression sprayer operating at 40 psi, equipped with two TXVS-18 hollow cone nozzles. Each treatment plot was 35 feet with an average of 9.9 trees per plot. Each treatment was replicated 5 times. On May 21, all trees were inspected for shoot borer damage. The number of trees in each treatment with damage, the total number of damaged shoots on all trees in each treatment and the number of damaged terminal leader shoots on all trees in each treatment were recorded for each tree inspected. The data were subjected to analysis of variance with significant means ($P<0.05$).

Results and Discussion: In past studies, the percent of trees in the untreated control with at least one shoot borer damaged shoot was 53 percent (1) and 53.6 percent (2). The percent of the untreated control trees with damage in the present study was 39.7 percent (Fig. 1). All three insecticide treatments had a lower percentage of trees with damaged shoots compared to the untreated control although only Talstar T & O was significantly different from the untreated control ($P=0.038$, Fig. 1).

Another important consideration for the grower is where the damage occurred on the tree. Damage to a side branch is not nearly as important as damage to the terminal leader which can result in a forked leader. In this study, there were no terminal leaders with damage in the Talstar T & O treatment which was significantly lower than the other insecticide treatments and the untreated control ($P=0.049$, Fig. 2). Additionally, the total number of damaged shoots per tree in the Talstar T & O treatment was significantly lower than the control ($P=0.032$, Fig. 3).

Significance to Industry: Early season control of*P. asesculana* using a properly timed application of Talstar T & O will allow for increased production of high quality red maple trees.

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Fig. 1 Percentage of Trees with Maple Shoot Borer Damage

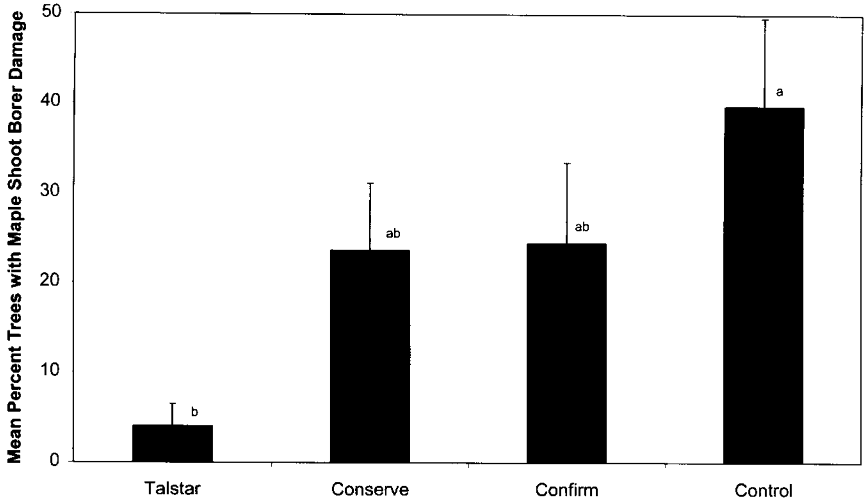


Fig. 2 Mean Number of Trees with Terminal Damage

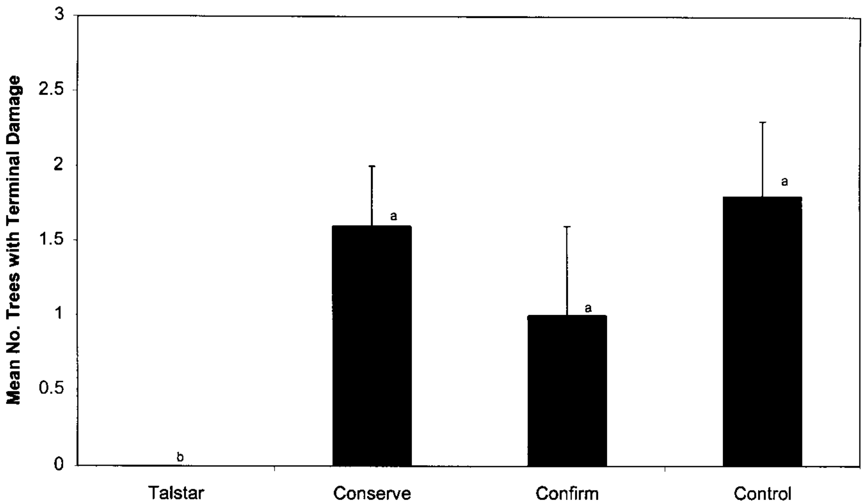
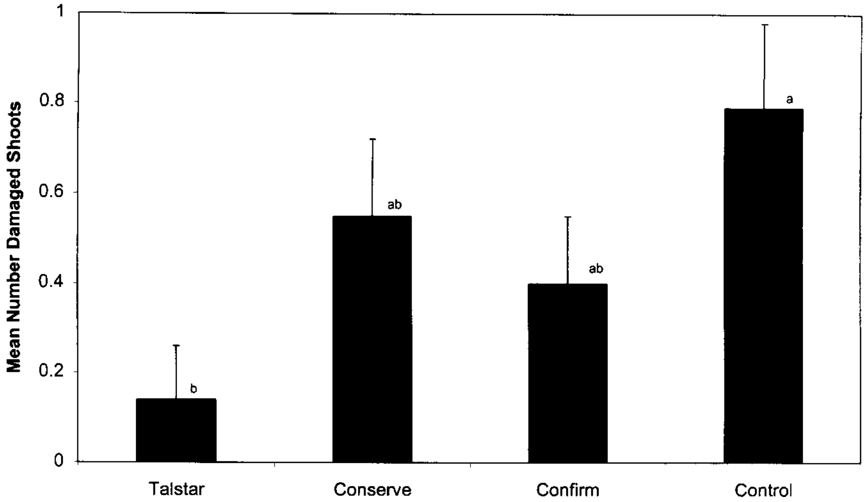


Fig. 3 Total Number of Damaged Shoots per Tree



Evaluation of Insecticides to Control the Asian Ambrosia Beetle, *Xylosandrus crassiusculus*

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Nature of Work: Insecticides to prevent attack of the Asian ambrosia beetle, *Xylosandrus crassiusculus*, were evaluated at Monticello, Florida on three tree species.

Three species of trees, Bradford pear, *Pyrus calleryana*, golden raintree, *Koelreuteria bipinnata*, and Kwanzan cherry, Prunus serrulata, were held bareroot in a cooler at <7ºC to delay budbreak and increase susceptibility to *X. crassiusculus* attack. Golden raintrees were ca. 2.5 cm diameter and <200 cm in height, Bradford pear and Kwanzan cherry were 1-2 cm by <100cm. Vane traps (1) were used to monitor adult emergence of *X. crassiusculus*. When beetles began to emerge, trees were removed from the cooler, placed in 3 gal pots with soil mix, insecticides were applied and 3 of 5 trees/treatment were baited with ethyl alcohol. Alcohol dispensers consisted of a small vial with a pipe cleaner protruding 1 cm. Single trees from each species x treatment combination were placed together at five different locations, 2 were unbaited and 3 locations had all baited trees to help increase the probability of attack. In the second week of the test newly attacked trees were placed in the unbaited locations. An untreated control versus the following insecticides were tested: acephate (Orthene TTO 75S), chlorpyrifos (Lorsban 4E), cyfluthrin (Tempo 2EC), cypermethrin (Ammo 2.5EC), fenpropathrin (Tame 2.4EC), methoxychlor (Marlate 50WP), permethrin (Pounce 3.2 EC) and sumithion (Pestroy 4EC). Trees were visually examined each day for gallery initiation and successful beetle attack. The test was run for 21 days but the majority of the attacks occurred during the first 7-10 days. The test was repeated after conclusion of the first test with new cooler-held, baited trees of the 3 species using only the control, Pounce and Tempo treatments, however, no trees were attacked. In the second test we included previously attacked trees at the test location to attract beetles. We used the number of trees attacked per treatment and the number of galleries per attacked tree as an indicator of insecticide efficacy.

Results and Discussion: *X. crassiusculus* began emerging in mid-February 1998 and immediately began attacking some of the test trees, but only the golden raintrees were attacked. The test was a fair success and provides a “tentative” indication of the efficacy of the insecticides tested (Table 1). We state “tentative” because neither all the control nor all the treated trees were attacked. However, to our knowledge this is the only field efficacy data available for this important pest other than Mizell et al. (2).

Only two of five control trees were attacked. The results indicate that only the synthetic pyrethroids had any effect in preventing beetle attack, with Pounce providing the lowest number of trees attacked (two) and galleries (1/tree) (Table 1). Orthene, Lorsban, Marlate, and Ammo had more trees attacked and as many successful galleries as the controls. Pestroy, and Tame had two attacked trees but a higher number of successful galleries than Pounce and Tempo
(Table 1).

Based on these tentative results Pounce and Tempo best prevent attacks from *X. crassiusculus*. Other test materials appear to be ineffective, however, more definitive tests are needed. Baiting the trees and holding the trees at low temperature to delay budbreak increased susceptibility because this is the first time we have induced *X. crassiusculus* to attack specific trees. Why the Bradford pear and Kwanzan cherries were not attacked remains a mystery because trees of similar size have been attacked in high numbers in previous years. Placement of freshly attacked trees in baited and unbaited locations appeared to have the greatest effect in attracting beetles to the vicinity of test trees. In one location, with both unbaited and freshly attacked trees, beetles attacked pot-bound pear trees that were located near the test trees but did not attack the test or the infested trees. In another location with baited trees under attack, beetles attacked nearby non-test trees, also. These observations suggest that an aggregation pheromone or plant volatile(s) released by attacking beetles may be a general *X. crassiusculus* attractant. However, other factors must play an important role in mediating tree selection and gallery initiation. Because of lack of understanding of beetle host selection behavior, research on *X. crassiusculus* is difficult and remains open to exploitation.

Significance to the Industry: Based on five years of experience with *X. crassiusculus* in Florida and knowledge of other Scolytidae we recommend the following. Build and use the Kovach trap (two 24 x 60 cm pieces of plexiglass in a “+” formation attached to a large collection funnel with collection vial at the bottom and baited with ethyl alcohol) to determine the emergence time of the adult beetles. Emergence usually centers around March 1 in Florida and Georgia, but peak emergence may occur one-two weeks earlier or later depending upon location and year. Once beetles appear in traps, scout the nursery for newly attacked Bradford pear, Kwanzan cherry, golden raintree, weeping willow, dogwood and any other species that is stressed or has not broken bud for whatever reason (including species shipped in from a more northern location which may increase susceptibility, as we have observed with dogwood in Florida). If galleries are found with fresh frass pushed out in a toothpick type formation, the diagnostic character, then apply Pounce or Tempo at that time. We cannot predict either which tree species or which individual trees will be attacked. Therefore, application of preventive sprays is usually not cost effective. Moreover, we do not know how long Pounce or Tempo will remain effective on the bark after application. Timing sprays to the first sign of attack seems to be the best option. If unusual cold spells occur during late February or March, expect delayed emergence. Traps will indicate when emergence occurs. Trees that are attacked in low numbers often survive. Trees that are attacked should be left in the nursery until the bole is fully attacked, then removed and buried or burned. This should reduce the number of trees attacked by increasing the total number of beetles in each attacked tree. Leaving the trees does not appear to increase the risk of attack on adjacent trees in locations where trees are naturally attacked. *X. crassiusculus* first brood do not appear to attack nursery trees when they emerge, because we do not see a second increase in attacks 30-40 days (approximate generation time) after the initial peak emergence time. We do observe attacks closely related to peaks in trap catch. We cannot accurately predict Asian ambrosia beetle population levels in 1999, but trends from 1993-1998 suggest that populations of this pest are decreasing in the deep South and increasing in the upper South.

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2. Mizell, R., S. Braman, B. Sparks and W. Hudson. 1994. Outbreak of the asian ambrosia beetle, *Xylosandrus crassiusculus* (Motschulsky), is cause for concern. Proc. SNA. 39:191-193.

Table 1. Efficacy of insecticides against the Asian ambrosia beetle, *X. crassiusculus*.

Treatment	Rate (Product/100 gal)	No. Trees Attacked	Mean No. of Galleries/Tree
Control	—	2a	16
Ammo 2.5EC	5.0 oz	3	9
Lorsban 4E	12.0 oz	4	6
Marlate 50WP	66.7 oz	3	15
Orthene TTO 75S	21.3 oz	4	5
Pestroy 4EC	4.3 gal		222
Pounce 3.2EC	8.0 oz	2	1
Tame 2.4EC	11.0 oz	2	11
Tempo 2EC	1.5 oz	2	4

[a] There were no statistical treatment differences detected in either parameter measured.

Control of Thrips and Fungus Gnats in Potting Media *(Student)*

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Nature of Work: Western flower thrips, *Frankliniella occidentalis* (Pergande), and fungus gnats *Bradysia* spp., are pests of ornamental production which spend part of their life cycle in potting media. Western flower thrips are a major pest of ornamental production worldwide (4). Thrips feeding damages plant foliage and flowers, they also vector tomato spotted wilt virus and impatiens necrotic spot virus. In 1996, thrips accounted for $6.9 million in damage to Georgia's ornamental crops. Another $6.3 million was spent on thrips control (2). Western flower thrips are difficult to control as a result of their high rate of resistance to insecticides (3). In addition, they are difficult to control because they pupate deep within the plants flowers or potting media making it difficult to get insecticides to them.

Although fungus gnats feed on fungi in the media, when fungi becomes scarce they feed on plant tissue. This damage is difficult to determine since it is caused by the larval stage feeding on the plant's roots. As a result, their economic value is probably understated. Their ability to transmit pathogens is also of concern (1). While natural enemies are available for fungus gnat control, insect growth regulators are currently the standard for control. The objective of this project is to evaluate soil applications for control of western flower thrips and fungus gnats.

Chrysanthemum 'Dark Charm' rooted cuttings were planted three per 6 inch plastic pot containing Metro Mix 300, 1 tsp 14-14-14 Osmocote, and were pinched after one week. The treatments were replicated five times with twelve pots per block. Western flower thrips introduction started March 9 and continued for three weeks, while the fungus gnats were a natural infestation. Soil treatments were made April 23, May 6, and May 20, except for Hypo-line which was only applied April 23 and May 20. The following treatments were applied at 2 fl oz per pot, except for Hypo-line which was applied at 1 tsp per pot:

Trade Name	Concentration	Scientific Name/ Active Ingredient
*Hypo-line	1 tsp / pot	*Hypoaspis miles* (predatory mite)
*ScanMask	3,700 / pot	*Steinernema feltia* (nematode)
*Naturalis-O	1 fl oz / gal	*Beauveria bassiana* (mycoinsecticide)
*Bio-Blast	1.3 oz / gal	*Metarizium anisopliae* (mycoinsecticide)
*Precision	0.4 oz / gal	fenoxycarb (insect growth regulator)

One 7 oz specimen cup with sides painted black and a Tanglefoot coated bottom was inverted and placed in the middle of one of two pots per block. After seven days the cups were removed and two new cups placed into two new pots. The number of thrips and fungus gnats collected each week were recorded.

Results and Discussion: Fungus gnats were prevalent in the greenhouse throughout the experiment. Naturalis-O resulted in higher populations than the other treatments from May 13 through June 10 (P<0.05) (Fig. 1). Since fungus gnats feed on fungal spores, this increase in population may be explained by the larvae feeding on the *Beauveria* spores in the Naturalis-O. Whereas Bio-Blast, also a mycoinsecticide, did not result in an increased fungus gnat population. Although not significant, the standard Precision provided the greatest fungus gnat control.

The thrips population was slow to build and only the last four samples showed significantly different means (Fig. 2). Precision and Bio-Blast treatments resulted in the lowest thrips population during the final four weeks (P<0.05).

Significance to Industry: Soil treatment for fungus gnat and western flower thrips control can become a vital component in greenhouse pest management programs. Media and foliar treatments made simultaneously to control western flower thrips would result in all non-egg stages being exposed to a control. By using a media treatment for fungus gnats that would also result in western flower thrips control, ornamental production may have a decrease in pest damage. Precision and Bio-Blast provided a significant (P<0.05) reduction in the thrips population. Reduction of fungus gnats, while not significant, was best achieved by using Precision.

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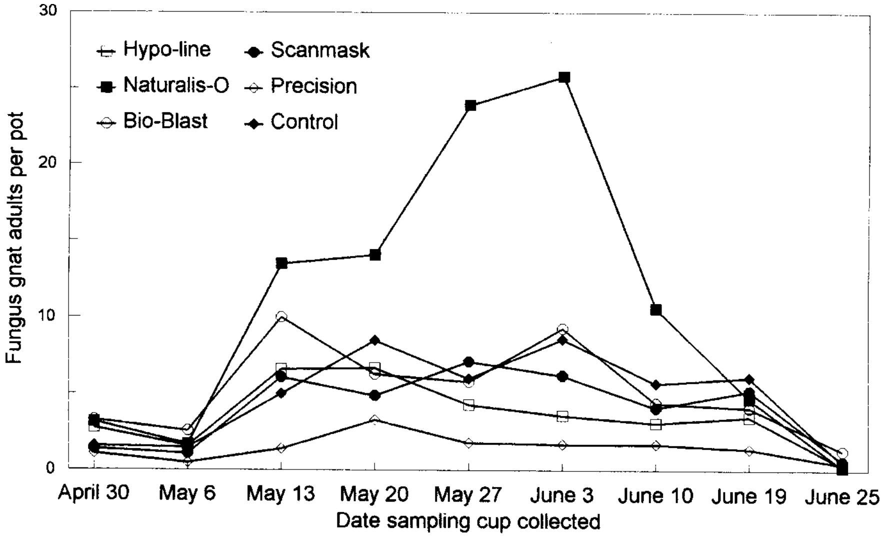

Fig. 1. Mean number of fungus gnat adults per pot.

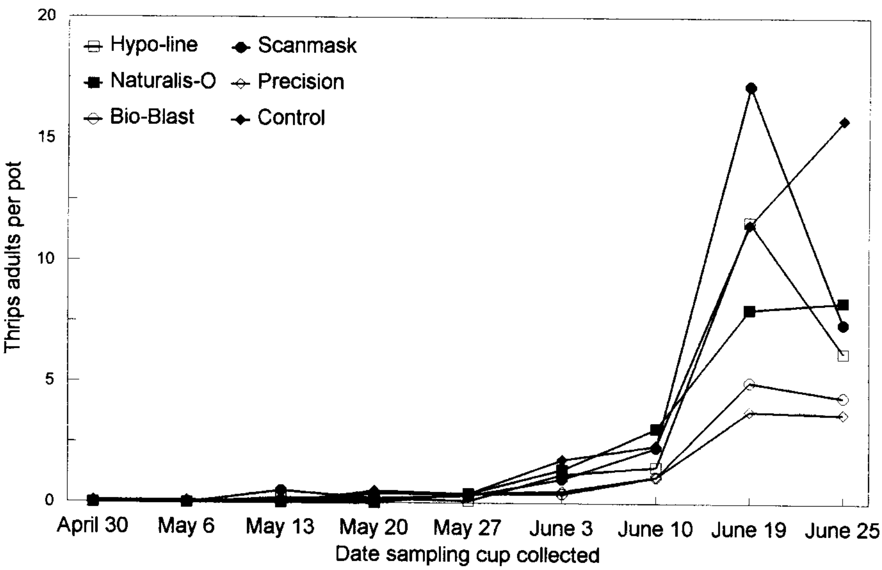

Fig. 2. Mean number of western flower thrips adults per pot.

Evaluation of Controls for Boxwood Leafminer

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Boxwoods (*Buxus* sp.) are popular landscape plants in commercial and residential designs. Thought to have been introduced to this country in the 17th century, they are commonly used in formal and informal plantings as specimen plants, screens, topiary and hedges. While 115 species and cultivars have been cultivated only three species and cultivars are used as ornamentals.

Insect pests of boxwoods are not always readily apparent. An example is the boxwood leafminer *Monarthropalpus flavus*(=buxi) Schrank, which infests *Buxus sempervirens* and its cultivars. The adult boxwood leafminer is a small, orange mosquito-like fly that emerges in late April from infested leaves. It oviposits into leaf tissue, and the larvae feed within the leaf creating a circular or blotched mine. The larvae overwinter in the leaf, and by the following spring their feeding has produced the blisters and dead spots on the underside of the leaves characteristic of boxwood leafminer infestation. The adult leafminers emerge in early spring.

Control efforts consist of foliar applications of insecticides to control adults and systemic applications to control feeding larvae. Pest management strategies for boxwood leafminer includes checking leaves for the presence of mines and placing yellow sticky cards in strategic locations to check for the presence of adult leafminers. The purpose of this study is to evaluate the efficacy of three chemical controls and a water check against the larval stage of boxwood leafminer.

Nature of Work: The study was begun on June 17, 1997. English boxwood plants infested with boxwood leafminer in 1 gal plastic containers were obtained from a Richmond Va. nursery and placed on a gravel pad with overhead irrigation. Treatments were Pinpoint 15G at 1.2 and 2.4 grams (1/4 and 1/2 tsp) per container; Orthene 75SP at 0.33 lbs per 100 gal (3 grams/ gal); Marathon 1G at 1.3 grams and 2.6 grams (1/3 tsp and 2/3 tsp) per container. Cygon 2E at 10 ml(2 tsp)/gal was used as a standard, and water was used as a check. Spray treatments were applied using an R&D CO_2 sprayer at 30 psi. The water check and Orthene spray treatments were applied July 7, 1997 with an ambient temperature of 85ºF. The Cygon spray and granular treatments of Orthene and Marathon were applied July 8, 1997 at an ambient temperature of 87ºF. There were four single plant replicates of each treatment.

Evaluation of the control measures were determined by counting the number of blistered leaves per plant on February 27, 1998.

Data were analyzed using Costat statistical software (Cohort Software, Minneapolis, MN 55419). Means of variables with significant differences were separated using Duncan's multiple range test.

Results and Discussion: The results of the study are shown in Table 1. The four granular treatments were significantly better than the check. The best results were achieved with the higher rate of Pinpoint 15G and both rates of Marathon. The spray formulations (Orthene and Cygon) did not differ significantly from the water check or the lower rate of Pinpoint. No phytotoxicity was observed in any of the treatments.

Table 1.- Boxwood leafminer control results.

Treatment & Rate	Mean
Check	64.5 a*
Orthene 75SP, 3 g/gal	46 ab
Cygon 2E, 10 ml/gal	39.3ab
Pinpoint 15G, 1.2g/cont.	21.5bc
Pinpoint 15G, 2.4g/cont.	2.75c
Marathon 1G, 1.3g/cont.	0c
Marathon 1G, 2.6g/cont.	0.5c

*Means having the same letter are not significantly different by Duncan's multiple range test. ($P<.01$)

Significance to Industry: Both Pinpoint (acephate) and Marathon (imidacloprid) were very effective in reducing levels of boxwood leafminer. Growers are reminded that the formulations and rates in this research project may not be registered.

Outdoor Labeled Miticide Evaluation for Control of Southern Red Mite

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Nature of Work: Mites continue to be one of the major pest groups on ornamental crops (1). Chemicals remain the preferred method of control in nursery situations. Due to the ornamental horticulture industry being minor in comparison to other areas of agriculture in the pesticide market, new materials are slow to be developed. This, along with a reluctance of companies to re-register current products, make chemical control challenging.

The Southern Red mite, *Oligonychus ilicis (*McGregor), is a common pest on ericaceous plants; primarily azaleas and camellias. This mite occurs in greatest abundance during the cooler months of the year. Feeding produces a bronze or brownish plant appearance followed by leaf drop, and is more pronounced with cooler temperatures.

This efficacy test was a recommended rate evaluation of foliar-applied miticides with a current outdoor nursery label. Infested *Rhododendron X* Robin Hill 'Redmond' azaleas growing in trade gallon containers of an amended pine bark-peat moss medium were used in this study. Treatments consisted of a single foliar-applied spray to all leaf surfaces to the point of runoff with the materials and rates listed in Table 1. A Spraying Systems Research Sprayer with TXVS-6 cone jet nozzle at 30 psi was used to make the treatment applications. No spray adjuvant was included. Plants were grown in full sun and irrigated with overhead impact sprinklers as needed. Live mite counts (Table 2) were recorded at 7, 14, and 28 days after treatment (DAT). Eggs were not counted. A Llanfair Orchard Leaf Brushing Machine was used to brush mites from three terminal shoots per plant onto a binocular microscope counting disc with grid. Each terminal shoot length was 4 inches.

Results and Discussion: At 7 DAT, plants treated with Hexygon 50WP, Kelthane T/O, Sunspray 6E, and Talstar F had significantly fewer mites when compared to the untreated check. At 14 DAT, similar trends were observed; however Talstar F failed to provide significant control. Hexygon 50WP, which is an ovacide/larvicide had considerably lower mite numbers than any other treatment, but was not significantly lower than Kelthane T/O or Sunspray 6E. At the last evaluation (28 DAT), Hexygon 50WP was all alone in providing significant control. The mites counted on the Hexygon 50WP treated plants at this time were almost all adult females.

Significance to Industry: In summary, this test indicates that a single application of the miticides tested is not sufficient to clean up a pre-existing infestation of southern red mite. Kelthane T/O, Sunspray 6E, and Hexygon 50WP appear to be our most effective treatments with Hexygon 50WP providing longer control.

Literature Cited:

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Table 1. Miticides and rates applied.

Treatment:	Rate/100 gal
1. Kelthane T/O	16 oz
2. Sunspray 6E	128 fl oz
3. Orthene TTO 75SP	10.7 oz
4. Tame 2.4EC	16 fl oz
5. Avid 0.15EC	4 fl oz
6. Hexygon 50WP	2 oz
7. Talstar F	38.4 fl oz
8. Untreated check	————

Table 2. Live mite counts from brushed azalea terminal shoots

Treatment*	Live Mites/ terminal shoots**		
	7 DAT	14 DAT	28 DAT
1. Kelthane T/O	25.5 c***	47.5 c	43.3 ab
2. Sunspray 6E	20.0 c	51.0 bc	50.5 ab
3. Orthene TTO 75SP	60.3 ab	109.3 a	30.3 b
4. Tame 2.4EC	64.5 ab	106.5 a	42.3 ab
5. Avid 0.15EC	61.5 ab	97.5 a	60.8 ab
6. Hexygon 50WP	28.0 c	8.8 c	4.3 c
7. Talstar F	44.5 b	88.3 ab	69.0 a
8. Untreated check	87.5 a	125.5 a	50.8 ab

*Treatment application March 24, 1998

**Mite counts are a mean of 4 plants

***Mean separation within columns by DMRT, p = 0.05

Biorational Plant Protectants for Controlling Adult Japanese Beetles

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Nature of Work: Japanese beetles, *Popillia japonica* Newman, are destructive, polyphagous insects that feed on over 300 different plant species, including many ornamental landscape plants. Since their introduction into the United States, Japanese beetles have spread rapidly throughout the Eastern United States with isolated populations in the Western United States and Canada. Due to the large numbers of beetles often present and their continual movement as adults, eradication of Japanese beetles is not a practical solution. In addition, pesticide applications in many urban settings are complicated by the proximity to people, adherence to reentry restrictions, and public concerns about pesticides. An alternate approach would be to deter pests with the use of low toxicity plant protectants including organic plant derivatives. As public concerns about pesticides increase, these plant protectants may provide desirable alternatives.

Plant protectants can be very effective at controlling Japanese beetles. Some synthetic insecticides (e.g., Sevin) function as effective protectants/antifeedants for adult Japanese beetles and rarely impact pest populations. Development of low toxicity protectants would broaden the choices in managing Japanese beetles. Currently, there are several products available for controlling Japanese beetle. The objective of this study was to field test commercially available plant protectants, including selected botanical derivatives, for their efficacy of deterring Japanese beetles.

The experiment, a randomized complete block design with 10 individual tree replicates consisted of 10 treatments. Treatments included six products formulated from plant derivatives, one bacteria, one pyrethroid, carbaryl as a common synthetic control, and an untreated control (Table 1). The experiment was conducted at both the Horticulture Field Laboratory (HFL), Raleigh and the Mountain Horticulture Crops Research Station (MHCRS), Fletcher (near Asheville). Himalayan birch [*Betula utilis* var. *jacquemontii* (Spach) Winkl] which is a preferred host for Japanese beetles, was used as the host species (Ranney and Walgenbach, 1992). Trees were approximately 30 inches in crown diameter, 6.5 ft high and spaced 8 ft apart when planted in March 1997. Each tree received 0.3 liters (10 fluid ounces) of each treatment solution applied via a diaphragm-type backpack sprayer from a single hollow cone nozzle at 40 psi. A preliminary study determined this volume was adequate to wet the upper and lower leaf surfaces on each tree. Treatments were applied between 7:00 AM and 9:00 AM June 19 at HFL and June 25, 1997 at MHCRS. Treatments were reapplied two weeks after initial application. At HFL, climatic conditions at application were partly cloudy, 65-70ºF, and wind of 0-5 MPH. Conditions were similar at MHCRS except temperature was 60-65ºF. All damaged leaves were removed prior to initial treatment application. Visual ratings of percent defoliation (skeletonization) were conducted weekly for five weeks following initiation treatment application by two independent evaluators at each location. Few beetles remained after the fifth week. Data were averaged over both evaluators at each location and subjected to analysis of variance (ANOVA). Treatment means were compared using least significant difference with P = 0.05.

Results and Discussion: There was a significant treatment x location x time interaction so weekly evaluation data is presented for each location (Fig. 1). Two weeks after treatment initiation, Tame significantly reduced feeding injury compared to the untreated control at both locations (Figs. 1A and 1B). Five weeks after the initial application, Tame averaged 2% and 3% defoliation compared to 40% and 100% defoliation of the untreated control at HFL and MHCRS, respectively. Rotenone also reduced Japanese beetle damage compared to the untreated control from weeks two to five at both locations excluding week five at MHCRS. Rotenone averaged 10% defoliation at HFL after 5 weeks, whereas trees averaged 92% at MHCRS. At HFL, from 3 to 5 weeks after initial application, Neemazad and X-CLUDE also reduced feeding damage compared to the untreated control. However, the reduction in damage was minimal. At HFL, Hot Pepper Wax, Garlic Barrier, M-Trak, Sevin, and Triact were never different from the untreated control (data not shown). At MHCRS, none of the treatments excluding Tame and Rotenone were significantly different from the untreated control (data not shown). The differences in treatment response may have been due to the differences in insect pressure and rainfall. HFL received 5.8 inches (0.6 in. during weeks 1-2, 4.8 in. during week 5) during the study period, whereas MHCRS received 7.3 inches (4.0 in. during week 1, 1.9 in. during week 3). There were no symptoms of phytotoxicity on any of the trees.

Significance to Industry: Eradication of Japanese beetles is not a viable option. Japanese beetles, however, have an extremely wide host range. Therefore, it may be practical to deter feeding from ornamental plantings to unmanaged vegetation. Tame was a very effective Japanese beetle deterrent, whereas Rotenone was moderately effective.

However, their LD_{50} oral ratings may limit widespread use. Thus, continued testing of naturally occurring compounds or synthetic analogues is desirable to find less toxic alternatives.

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Table 1. Treatments applied to Himalayan birch trees.

Product	Pesticide	Rate
Untreated control	water	——
Hot Pepper Wax	3% capsaicin	4.0 fl oz/gal
Garlic Barrier	garlic extract	12.5 fl oz/gal
M-Trak	10% Bacillus thuringiensis var. san diego	3.0 fl oz/gal
Neemazad 4.5EC	azadirachtin	0.15 fl oz/gal
PT70 X-CLUDE	1.1% pyrethrin	2.0 fl oz/gal
Rotenone 5WP	rotenone	3.3 oz/gal
Sevin 4F	carbaryl	0.5 fl oz/gal
Tame 2.4EC	fenpropathrin (synthetic pyrethroid)	0.35 fl oz/gal
Triact 90EC	neem oil extract	0.85 fl oz/gal

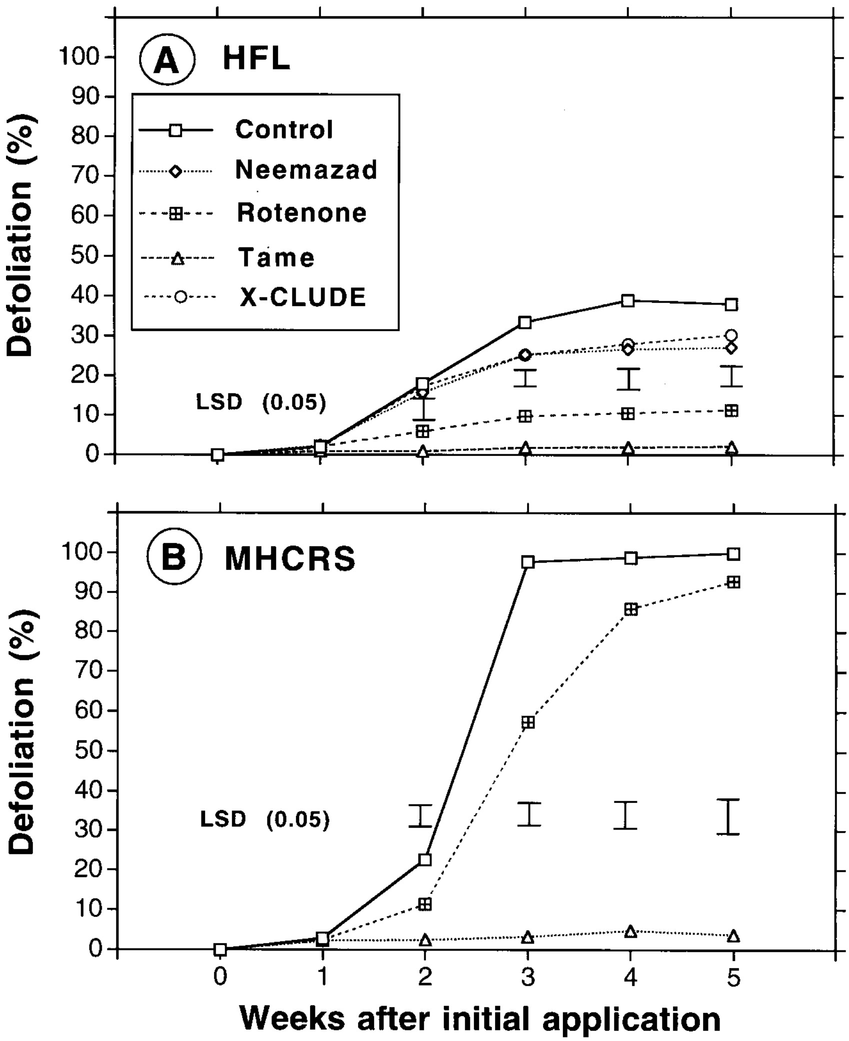

Fig. 1. Percent defoliation of foliage of Himalayan birch treated with different pesticides. Only treatments that differed from the control are presented.

What Factors Affect Twospotted Spider Mite Populations on Burning Bush?

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Nature of Work: Burning bush, *Euonymus alata*, is commonly planted for its brilliant red fall foliage, but is susceptible to outbreaks of twospotted spider mite, *Tetranychus urticae* Koch, which cause chlorosis and premature leaf abscission at high population densities (Smitley and Peterson 1991). We hypothesized that cultural factors such as planting site (full sun or proximity to a structure), water availability, and fertilization could increase the reproductive rate of the mites by providing them with a more suitable food plant or environment (Sabelis 1985).

Shading effects were tested using two shading levels; 30 and 60%, or full sun. A plot of 18 *E. alata* were planted in pot-in-pot production. Shade huts were 1.07 m high and 1.5 m wide at the base and were placed over the plants. The plants were allowed to break bud under their respective treatments and then were infested with 50 female mites in July. Mite populations were allowed to build and were sampled in September via whole-leaf counts on 50 leaves per plant.

To study interactions between planting site temperature, and mite population growth 24 *E. alata* were planted near or away from a 9.75 m cylinder block wall. The wall was constructed on an east/west line and was painted black. Six replicates were planted 0.6 m or 6.1 m away from the wall on the north and south sides. Plants were infested in July and were subsequently sampled in September, as discussed above.

To study effects of water stress and plant nutrition, 36 plants were planted in pot-in-pot production and fertility and watering regimes were manipulated. The two fertility regimes were no fertilizer added and fertilized with Osmocote 18-6-12 at 68g per 11.4L. Watering regimes consisted of well-watered (watered three times daily), cyclic drought (watered once every other day), and chronic drought (watered upon wilting point). Soil moisture and plant water potential were monitored with tensiometers and a pressure chamber respectively, and foliar nitrogen levels were determined by Kjeldahl analysis. Natural rainfall was excluded from the plants by covering the pot with plastic. The plot was mulched to prevent excess heat from affecting the plants. Plants were infested and sampled as before.

Results and Discussion: *Sun vs. Shade.* Full sun plants had greater leaf water content and thicker leaves than did shaded plants. However, total mite populations and total number of leaves infested did not differ significantly between the three treatments.

Temperature Stress. Mite populations were significantly higher by the wall and on the south side (Fig. 1). Temperature readings were also significantly higher on the south side, near the wall, than away from the wall or on the north side, near the wall. There was significant interaction of direction and wall on mite densities. However, none of the leaf parameters differed significantly among planting sites, implicating temperature as the main cause for the differences in mite populations.

Water Stress and Nutrition. Well-watered plants had significantly more total mites and total infested leaves than did cyclic or chronic drought-stressed plants (Fig. 1). However, fertilization had no effect on mite populations. Pressure bomb readings confirmed that well-watered plants were under the least amount of moisture stress, followerd by cyclic and chronichally drought stressed plants. Well-watered plants had significantly thicker, more succulent leaves than did drought-stressed plants (Table 1). Visual color rating showed that well-watered and unfertilized plants had the best red fall color, whereas chronic drought and fertilized plants had the least amount of fall color.

Significance to the Industry: Characterizing the environments that provide twospotted spider mite populations with optimal reproductive conditions will be helpful in managing mite problems on *E. alata*. This work suggests that well-watered burning bush planted on the south side, close to homes or other structures may be especially prone to mite outbreaks. These locations should be the first areas in the landscape inspected for mites, allowing timely control, when warranted, to prevent further growth and spread of mite populations. Planting E. alata in cooler, less severe locations (e.g. the north side of structures) may reduce their susceptibility to mites.

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Table 1. Physical characteristics of winged euonymus leaves under various environmental regimes

Water Regime	Thickness(um)	Toughness(g)	Area(mm)	Water Content(ul)	Color Rating
Well	254.8 ± 5.1a	251.7 ± 14.3	689.6 ± 24.7	270.0 ± 15.8a	3.7 ± 0.4a
Cyclic	238.5 ± 4.2ab	238.1 ± 14.5	632.3 ± 27.6	214.1 ± 18.8b	2.8 ± 0.3b
Chronic	228.6 ± 5.4b	283.7 ± 14.3	636.5 ± 25.7	210.2 ± 12.2b	2.1 ± 0.3c
Fertilization Regime					
Fertiilzed	243.6 ± 4.6	257.8 ± 13.8	655.4 ± 22.5	235.2 ± 14.1	1.9 ± 0.2b
Unfertilized	237.7 ± 4.1	257.9 ± 11.5	644.2 ± 20.3	227.6 ± 14.5	3.8 ± 0.2a
Exposure					
30% Shade	187.9 ± 9.5a	247.3 ± 14.4	483.8 ± 37.0	78.2 ± 8.3	NA
60% Shade	145.4 ± 6.3b	233.8 ± 11.4	440.0 ± 22.7	58.8 ± 3.4	NA
Full Sun	191.4 ± 12.6a	236.0 ± 14.0	431.4 ± 24.4	88.3 ± 8.6	NA

Means followed by the same letter are not significantly different at $p<0.05$.

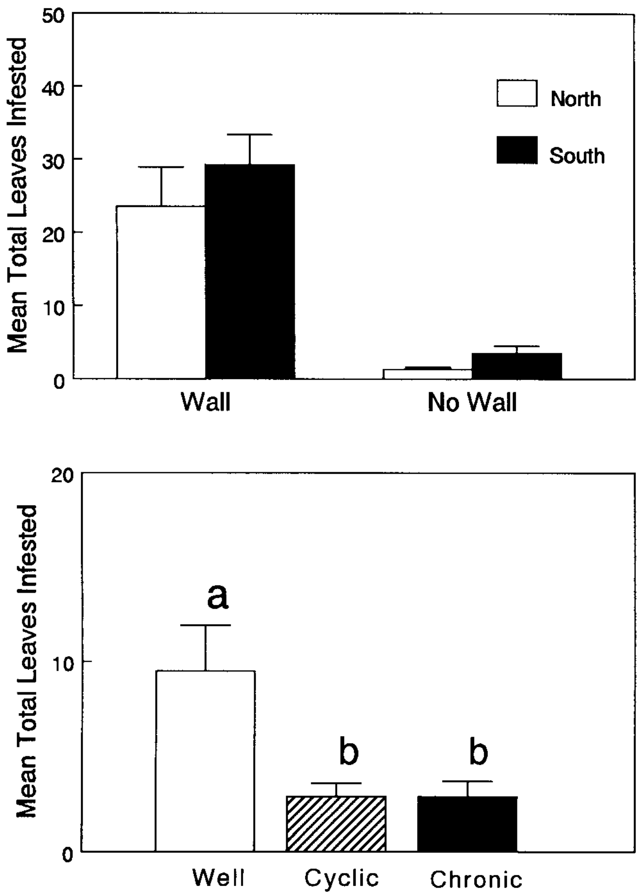

Figure 1. Comparison of temperature, water and nutrition on mean total leaves infested

Whole Plant CO_2 Exchange Measurements on Azaleas Injured by Azalea Lace Bug Feeding

(Student)

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Nature of Work: The azalea lace bug, *Stephanitis pyrioides* (Scott) is the most significant pest of cultivated azaleas in the southeastern landscape (2,11). Azalea lace bugs feed on cell contents within the palisade parenchyma and cause a readily apparent chlorotic stippling on leaves (7). Measurements made on single lace bug-injured azalea leaves demonstrate reduced photosynthetic rates. These reductions were correlated to the removal of leaf chlorophylls and other cellular contents (4). Additionally, analysis of single azalea leaf CO_2 exchange indicated that azalea lace bugs impair chlorophyll functioning in the remaining chloroplasts. This effect was attributed to corresponding stomatal closure in injured leaves (4).

Welter (13) reviewed the effects of arthropod and insect feeding on plant gas exchange within insect feeding-guilds. The majority of these studies also relied primarily on measurements of leaf gas exchange taken from individual leaves. Evans (6) cited several factors that may result in a poor correlation between single leaf photosynthesis measurements and both dry matter production and yield. Leaves selected for measurement are known to vary with age or condition. Analysis of a particular stage of leaf maturity is not necessarily representative of the overall photosynthetic rate of a plant canopy. Variability may also exist within a single leaf. The section of leaf chosen for measurement may not be typical of the whole. Collection of the many samples needed for statistical accuracy virtually ensures that leaf samples will be conducted over a lengthy time period. Variation, due to diurnal changes in photosynthetic rate, is likely to confound the data. Most importantly, root and shoot respirations are not measured. Growth and carbon use efficiency variables are not adequately quantified and cannot be reliably interpreted.

The shortcomings of individual-leaf gas-exchange analysis may be avoided by using whole-crop CO_2 exchange systems usin a growth chamber (3,5,12). Environmental conditions, including CO_2, temperature, light, and relative humidity variables are effectively maintained facilitating data interpretation (12). We undertook a whole-crop analysis of gas exchange in Girard's 'Pleasant White' azalea hybrids. Rooted azalea cuttings were maintained at 20°C for a 10:14 (L:D) photoperiod. A single acephate application (ml/l) was made on 42 undamaged control cuttings to maintain them in a lace bug-free condition during the study. Using 1.0m3 screen cages, cuttings were artificially infested to obtain low (6%), medium (13%), and high (31%) leaf area injury treatments.

Injury was quantified by comparing 1/2 of the leaves on each cutting to an array of 24 leaf images ranging from 0.5% to 82% injured leaf area. Leaf images were analyzed using Mocha software: a computer-assisted measurement program which utilized contrasting color overlays to quantify both total leaf area and injured leaf area (Jandel Laboratories, San Rafael, CA). Percent injury on each leaf was estimated for the 7 cuttings in each treatment group. Previous work on azaleas has indicated that leaf damage may be recognized when 2% or more of the leaf area is injured by feeding azalea lace bugs (W.E.K. unpublished data). We used this 2% threshold to calculate a mean proportional injury level for the 7 azalea cuttings included within each treatment group. Leaves with less than 2% injury among the leaf area were not counted as injured for this proportional level.

Treatment groups, each consisting of 7 azalea cuttings, were randomly selected from the 42 plants in each treatment level. Treatment groups were arranged into 6 replicates and together formed a randomized complete block design. Plants were watered before being placed in the chambers to alleviate potential water stress. In the chambers, treatment groups received a 14L:10D photoperiod. Photosynthetically active radiation (PAR) levels at canopy height averaged 600 (μol m^{-2} s^{-1}. Relative humidity within the chambers was held at 50% during the day and increased to 70% during the night. Diurnal temperatures in the growth chambers were maintained at 23 $\pm$ 1°C while nighttime temperatures dropped to 19 $\pm$ 1°C.

A multi-chamber whole plant CO_2-exchange system (12) measured net photosynthesis (P_{net}) and dark respiration (R_{dark}) for treatment groups during a 24-hour period. Gas exchange measurements, lasting 5 minutes per chamber, were taken sequentially for each treatment. Treatment groups, replicated 6 times, were analyzed in 3 trials lasting 24 hours each. Each trial consisted of 2 complete replicates as well as measurements taken within 2 empty acrylic chambers, which provided a baseline for comparison. Carbon use efficiency (CUE) is the ratio between carbon incorporated in plant dry mass and the total amount of carbon fixed in photosynthesis. Daily carbon gain (DCG) is the amount of CO_2 fixed by the canopy less the amount of CO_2 lost by respiration and is similar to crop growth rate. Long-term experiments using summed DCGs to provide a cumulative carbon gain (CCG) have found a close correlation

(r^2 = 0.998) between cumulative carbon gain and plant dry mass (12). Carbon use efficiency, daily carbon gain, and gross photosynthesis were calculated from P_{net} and R_{dark} data. Once gas exchange measurements were concluded, leaves were removed from each plant and 25 leaves were randomly selected. Leaf area of the 25 leaves was determined using a LI-COR 3200 leaf area meter. Dry mass of the 25 leaves was taken, as well as dry masses of the leaves, stems and roots of each treatment group.

Results and Discussion: Injury levels imposed by artificial infestation was 6% actual leaf area injury for the low level treatment, or 42% proportional injury based on the 2% threshold. The medium treatment had 13% actual leaf area injury and 61% proportional injury, and the high treatment had 31% actual leaf area injury and 76% proportional injury.

Measurements of gas exchange taken from whole plants revealed differences among treatments of azalea lace bug-injured leaf area. Net photosynthesis in the high treatment, with 31% of the canopy leaf area showing azalea lace bug injury, had lower net photosynthesis than undamaged, low, or medium injury treatments. Dark respiration results revealed that both the medium (13% actual leaf area injury) and high (31% leaf area injury) levels were lower than respiratory rates demonstrated by undamaged and low (6% leaf area injury) treatments.

All injury levels presented different efficiencies of carbon use. The treatment having the highest level of injury demonstrated the least efficiency in carbon use: only 63.1% of the total carbon fixed by photosynthesis was attributed to dry mass production. Efficiency levels for undamaged, low and medium injury treatments exhibited a trend suggesting that carbon use efficiency increased with ALB feeding injury. Instead, the interaction of net photosynthesis and dark respiration were illustrated by these results. The trend described by daily carbon gain values closely paralleled that of net photosynthetic rate. Only plants averaging 31% actual leaf area injury had notable reductions in growth.

Significance to Industry: Azalea lace bug management practices have historically focused on chemical controls (1,10). In 1995, landscape managers, nurserymen, and homeowners spent in excess of $1.1 million to control lace bugs, including *Stephanitis pyrioides*, in Georgia alone (9). Heavy reliance on chemical controls has prompted investigations into integrated management programs for azalea lace bug. The results of this study suggest that azaleas are resilient under azalea lace bug feeding pressure. The proportional values of azalea lace bug injury demonstrate that plants in all selected treatment levels would be readily recognized as damaged in the landscape. Urban pest management programs in the southeast should work to increase consumer tolerance of lace bug injury. Additionally, the importance of plant placement and landscape structure should be emphasized as effective tools in mitigating population outbreaks of azalea lace bugs (8).

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Management of Insects and Mites on Nursery Stock with Soybean Oil
(Student)

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Nature of Work: Johnson and Caldwell (1987) surveyed the nursery industry and reported that oil sprays are most frequently used for mite and scale insect control. A large percentage of the growers surveyed reported "acceptable to complete control" of scale insects and mites with petroleum oil. Our previous research has shown that dormant applications of soybean oil controlled scale insect and mite pests of orchard crops (Pless *et al.*, 1995) In addition to being the most abundant vegetable oil in the United States, soybean oil is environmentally friendly, has a nontoxic, physical mode of action; and is exempted from EPA registration (not if a pesticide claim is made.) The objectives of this research were to determine if soybean oil would 1) control insects and mites on nursery stock as a summer spray, 2) control scale insects on nursery stock as a dormant spray, 3) affect photosynthesis and transpiration, and 4) cause phytotoxicity.

In Experiment 1, field grown 'Globe' arborvitae plants growing in McMinnville, TN, were identified as infested with a large population of Fletcher scale *Parthenolexanium fletcheri* (Cockerell). This experiment investigated the efficacy of dormant applications of soybean oil for control of Fletcher scale. Sprays of 0 (water control), 2, 3, or 4% soybean oil (v/v in water) (emulsified with Latron B-1956 at 10 % of the respective oil concentration) were applied on 9 March 1997 with a 3-gallon Stilh SR400 backpack mist blower. The treatments were in a randomized complete block design with six replications, each with two plants per experimental unit. On 13 March 1997, twig samples were collected and Fletcher scale mortality was assessed by evaluating 100 scale insects per experiment unit.

In Experiment 2, summer sprays of soybean oil were evaluated for efficacy of the cotton aphid, *Aphis gossypii* (Glover), on hibiscus and for effects on photosynthesis and transpiration of the plants. Seedlings of 'Southern Belle Mixed' (*Hibiscus moscheutos*) were transplanted on 24 April 1997 into trade gallon pots (approximately 3 liters) filled with 'Pro Mix BX' potting soil and grown in a research greenhouse at Knoxville. Six weeks later, the plants were divided into groups A and B containing 30 plants each. Group A was maintained "insect-free" through regular sprays of Orthene, Azatin, Enstar II, and Savey. Group B was considered "insect infested" and maintained in a separate enclosed section of the greenhouse. The plants from the "insect-free" group (A) and the "insect-infested" group (B) were sprayed on 2 June and 11 June, 1997, respectively, with 0 (water control), 0.5, 1.0, 1.5, or 2.0% soybean oil (v/v in water) or 1.0% Sunspray Ultra-Fine horticultural oil (standard). The plants were sprayed until runoff with a backpack airblast sprayer. Treatments were arranged in a randomized block design with five single plant replications.

Initial aphid population estimates (visual counts) were made on 28 May 1997 (prior to spraying) to establish the presence of more than 100 cotton aphids per plant. Populations of aphids were determined through whole plant counts. Daily examinations were made for phytotoxicity utilizing a five-point phytotoxicity scale (Davidson *et al.*, 1990): 1 = no visible damage, 2 = slight yellowing of some leaves, 3 = moderate yellowing of most leaves, 4 = burn, no dieback, 5 = dieback. Photosynthesis, respiration, and transpiration were measured on the fifth to eighth leaf from the apex of each plant on 1, 3, 7, and 14 days after spraying. Measurements were made with an ADC-3 portable infrared gas analyzer (Analytical Development Company, Hoddesdon, UK).

In Experiment 3, summer applications of soybean oil were sprayed to determine the efficacy on spider mites. Johnson (1988) reported that the two-spotted spider mite, *Tetranychus urticae* (Koch), is one of "the most widespread, destructive, and ubiquitous spider mites in the entire family." Container-grown 'Burning Bush' Euonymus plants in Knoxville, TN were sprayed on 20 September with a backpack mist blower with 0 (water control), 1.0, 2.0, or 3.0% soybean oil (emulsified with Latron B-1956 at 105 the oil rate); with 1.0% SunSpray Ultra-Fine petroleum oil; or with 0.1% Latron B-1956. Adult mites were collected with a mite brushing machine (Leedom Enterprises, Palo Alto, CA) 7 and 14 days after treatment. Collected mites were stored in vials of ethanol and counted at a later date.

Results and Discussion: In Experiment 1, dormant application of 2, 3 and 4% soybean oil controlled more than 98% of Fletcher scale on field grown 'Globe' arborvitae. Thus, soybean oil can be an effective dormant season insecticide for scale insects.

In Experiment 2, aphid populations on *Hibiscus* plants were reduced for 27 days compared to populations on control plants after spraying 2 or 3% soybean oil. However, this preliminary research indicated that populations need to be monitored more carefully, since aphids reproduce rapidly. Thus, summer sprays of soybean oil can reduce populations of aphids but more research is needed and is currently being conducted to determine optimum control methods.

In experiment 3, summer applications of 1 or 2% soybean oil controlled greater than 97% of two-spotted spider mites 7 and 14 days after treatment. Photosynthesis and transpiration were reduced on the *Hibiscus* plants for up to ten days after treatment. After this time period, rates of gas exchange were equivalent to those of the control plants. However, many other pesticides also cause a reduction of photosynthesis (Ayers and Barden, 1975). Future research should determine if the reduction in transpiration reduces water stress. No phytotoxicity was observed on any of the plants in any of the three experiments.

Significance to Industry: Soybean oil is an environmentally-safe, renewable resource that effectively controls insects and mites without producing phytotoxicity on most plants. Because oils control insects and mites by a physical mode of action (smothering) it very unlikely that insect/mite pests will develop resistance. Use of soybean oil as an insecticide or miticide may be especially desirable in urban environments since it is nontoxic to mammals.

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IPM Scout Training in Florida

(Poster)

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Nature of Work: Crop losses due to pests can account for up to 20% of total production volume. Increased pest resistance, chemical costs, and public concern over environmental risks, coupled with fewer pesticides being re-registered, has increased the need for alternatives to conventional pest control methods. One alternative is Integrated Pest Management (IPM). Using this approach, strategies can be developed to decrease crop losses, reduce pesticide costs, and save growers money.

Scouting, the regular monitoring of a crop for insects and diseases, and documentation of potential problems, is an important component of an effective IPM program; however, personnel qualified to perform scouting tasks are limited. A training program was developed to emphasize frequent monitoring and effective integration of cultural, mechanical, biological, genetic and chemical control methods in order to improve the production capabilities of growers. An IPM scout training program began in central Florida to increase the use of IPM. Since 1995, this program has become a statewide effort in four major production regions. The program involves teamwork between extension agents and university specialists.

Results and Discussion: Horticultural extension agents, along with entomology, plant pathology and nematology specialists developed the curriculum and determined the time required to achieve the desired level of training. Thirty-two contact hours — divided into two half-day sessions and three full-day sessions — were deemed adequate. Hands-on practice, one-half day in a greenhouse and one-half day in a container nursery, was considered essential for the training.

The curriculum included:

- Benefits of Scouting
- Scout / Management Negotiations
- Mechanics of Scouting
- Record Keeping
- Scouting for Insects
  - Basic Entomology
  - Injury Symptoms
  - Equipment
  - Methods
- Key Plant / Key Pests
  - Identifying Insects
  - Sample Submission
  - ID Resources
- Scouting for Diseases
  - Basic Plant Pathology
  - Symptoms / Signs
  - Equipment
- Key Plant / Key Diseases
- Scouting for Nematodes
- Scouting for Abiotics
- Mistaken Identities
- Beneficial Insects & Organisms
- Selecting Diagnostic Labs
- Monitoring Media pH and EC
- Scouting Resources

A list of materials needed for each student was established. This included a 10x hand lens, a clipboard, and an updated UF Scouting Manual. This manual was a “reference book” of extension bulletins and other pertinent information that included: color photos of insects, diseases, nematode problems, beneficial insects, fungi and descriptions of commonly misdiagnosed problems.

Training programs were marketed to the horticultural community using several techniques. Methods included direct mail brochures to nurseries, announcements at professional association meetings, listings in calendar sections of trade magazines and association newsletters, bulletin boards at local community colleges, personal contacts during meetings and nursery visits, and word of mouth, particularly from past participants.

Marketing is instrumental to the programs success. Thus, promotional materials and an attractive brochure, containing a registration form, are essential. Registration fees were determined by adding costs of the materials, lunches and refreshments (for breaks), and speakers’ travel expenses. Total fees came to $175 per person. Sponsorship money was available to defray some costs.

Scheduling and location issues included availability of a room adaptable for slide presentations and within reasonable distance to nurseries. Time of year is important so that training doesn’t interfere with seasonal work, yet it is also wise to choose a season when pest problems are prevalent. Experience has shown that a class size of 10 –15 people is best. Instructors included University of Florida specialists, whose expertise and knowledge base provided depth to the training, and trained extension agents, whose hands-on experience in the field gave breadth to the students’ experiences.

The intended audience was nursery employees (selected by their employer) or independent scouts who already had an employment contract. However, participation was open to anyone with a keen eye for details and the ability to notice changes. Plant and/or pest experience was helpful but not necessary. Participants should have good record keeping skills.

Follow-up meetings are scheduled every 3–6 months after each class. These meetings are designed to encourage scouts to share information, techniques and knowledge with others who have completed the program. Scouts are also encouraged to participate in a program that reports their findings on the Internet. This information can be used to predict recurring events in order to prepare for effective control methods. The web address for this information is http://www.ifas.ufl.edu/~apkweb/

Fifty-six scouts were trained in 1998 — 42 were employed by nurseries, and 14 were independent scouts. A certificate of completion, was presented to each student that finished the class.

Significance to Industry: Implementation of an IPM program based on scouting can increase profits, decrease hazards to employees and the environment, and reduce risk of regulatory penalties. Other IPM programs have affected a 45% reduction in pesticide application by participating nursery growers. Scouting makes growers more aware of problems, helps detect problems early, thus allowing broader choices for control methods that, in the long term, can reduce chemical use. Growers should see dramatic improvement in their public image as they become more responsible environmental stewards and competitors in a difficult market.

While scouting is an important component of an effective IPM program, net savings may not occur automatically. In order to realize a financial savings, a grower who pays for 50 hours of scouting needs to reduce chemical usage by more than 7.5%; however, improved techniques for managing pests could enable growers to also reduce environmental and worker risks associated with indiscriminate chemical use.

Tiphia vernalis, A Parasitoid of Japanese Beetle
(Student)

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Nature of Work: Japanese beetle (*Popillia japonica* Newman) was accidentally introduced into the U.S. and very quickly became a significant pest due to the favorable climate, abundance of host plants, and lack of natural enemies (1). In Japan, the native country, Japanese beetle has not been considered an economic pest, suggesting that natural enemies have played an important role in regulating the population. Tiphiidae is the dominant group of hymenopterous parasites attacking grubs in the Far East (2). These wasps are solitary, develop externally on late instar host grubs, and usually have one generation per year. As a result of collection efforts in Japan, Korea, and China in the 1920's by the USDA, several species of Tiphiidae were imported for biological control of Japanese beetle. *Tiphia vernalis* Rohwer, one of the imported species, was released in New Jersey in 1925. From 1928 to 1950, T. vernalis was established and abundant at numerous sites and was credited for reducing Japanese beetle populations (3). Since the 1950's, however, much of this work was discontinued and most of the populations of *T. vernalis* disappeared. *T. vernalis* has been most recently reported in Ohio, North Carolina, Indiana and Tennessee. Renewed interest in T. vernalis for management of Japanese beetle has generated efforts to re-evaluate and improve techniques in collecting, transporting, rearing, and releasing T. vernalis for biological control of Japanese beetle.

The objectives of these tests were to evaluate rearing containers (three sizes of plastic containers and one size glass vial) and number of grubs per container for maximizing rearing of *T. vernalis*. Each rearing container type was tested independently of the other container types and the number of replications varied among tests due to availability of *T. vernalis* and Japanese beetle grubs. Data from the container tests were compared for the level of parasitism achieved and the subsequent formation of parasite cocoons. One Japanese beetle grub (3rd instar) was placed in each container filled with a sand-peat moss mix. After the Japanese beetle grub had moved down into the soil, one female *T. vernalis* was placed in each container. One, two or four days after the introduction of the parasite, the grub was removed and examined for the presence of an egg or parasite. Each parasitized grub was returned to the container for cocoon formation. Approximately one month later, each container was examined for the status of the parasite (i.e., if a cocoon had been formed).

Two tests were conducted to evaluate parasitism relative to the number of grubs per container. Treatments consisted of 1, 2, 3, 4, or 5 Japanese beetle grub(s) (3rd instar) per container. The 710 ml (24 oz) containers were filled with a sand-peat moss mix. One female *T. vernalis* was introduced into each container after the grub(s) had dug down into the soil mix. Treatments were replicated 5 times in both tests. In the first test, the grubs were examined for parasitism 24 hours after *T. vernalis* was introduced and in the second test, 48 hours after *T. vernalis* was introduced. Each parasitized grub was placed in a cell of a multi-celled plastic tray containing the sand-peat moss mix for cocoon formation. Approximately one month after exposure, each cell was examined for the presence of a cocoon.

Results and Discussion: Four container types were evaluated for rearing *T. vernalis*. The highest percentage of parasitism and subsequent cocoon formation was observed in the 710 ml (24 oz) plastic container in which the grub was exposed to the parasite for two days (Table 1). As the number of grubs increased in a container, the level of parasitism was significantly ($P<0.05$) reduced (Tables 2 and 3). Parasitism was always greater for Japanese beetle grubs exposed to the parasite for 2 days compared with grubs exposed to the parasite for 1 day, regardless of the number grubs in the container. These tests corroborate past research that *T. vernalis* can be laboratory reared. However, previous efforts to rear *T. vernalis* resulted in 40% of the grubs parasitized and 50% of the parasitized grubs resulting in a cocoon.

The goal of rearing *T. vernalis* is to maximize the number of cocoons or adult T. vernalis produced. Currently adult *T. vernalis* are collected in the field which can be laborious and time consuming. Additionally, the period of time in which adult *T. vernalis* can be collected is relatively short and the quality and age of field-collected adults are unknown. Therefore, laboratory rearing of *T. vernalis* would greatly enhance the use of these parasites in Japanese beetle management. The type of rearing container and the parameters of exposing the host insect to the parasite can be important in maximizing the efficiency of rearing. Small rearing containers would be preferred to larger rearing containers because they would require less storage space, less soil mix per container, and would be easier to manipulate. More tests are necessary to determine the most suitable parameters for maximum efficiency of rearing *T. vernalis*.

Significance to Industry: There is a tremendous concern about the continuing spread of Japanese beetle through artificial means. Any efforts that can contribute to the reduction of a population of Japanese beetle and thereby, reduce the risk of spread would be beneficial to both the shippers and receivers of plant material. Biological and cultural control efforts are particularly beneficial because they may cause decreased reliance on pesticides and result in a long-term reduction of Japanese beetle populations. Introducing and encouraging establishment of *T. vernalis* in areas with significant Japanese beetle populations may contribute to the long-term reduction of the population. Methods to rear *T. vernalis* would enhance our ability to release *T. vernalis* in the field and these tests indicate that rearing may be accomplished successfully in the laboratory.

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Table 1. The percentage of 3rd instar Japanese beetle grubs parasitized and the percentage of cocoons when a single grub is exposed to a female *Tiphia vernalis* in the laboratory.

Type of Container	n	Days Exposed	% Grubs Parasitized	% T. vernalis Cocoons
710 ml (24 oz) plastic	5	1	80.0	0.0
710 ml (24 oz) plastic	5	2	100.0	80.0
100 ml (3.4 oz) plastic	55	1	78.2	55.8
100 ml (3.4 oz) plastic	20	2	95.0	21.1
28 ml (0.9 oz) plastic	20	2	68.4	46.2
28 ml (0.9 oz) plastic	20	2	85.0	52.9
25 ml (0.8 oz) glass vial	16	4	75.0	25.0

Table 2. The percentage of 3rd instar Japanese beetle grubs parasitized and the percentage of cocoons when exposed to a single female *Tiphia vernalis* inthe laboratory.

No. Grubs per Container	% Grubs Parasitized	% *T. vernalis* Cocoons
1	80.0 a	0.0 a
2	40.0 ab	0.0 a
3	20.0 b	0.0 a
4	15.0 b	33.3 a
5	4.0 b	100.0 a

Percentages in a column followed by the same letter are significantly different by Tukeys Test (P<0.05)

Table 3. The percentage of 3rd instar Japanese beetle grubs parasitized and the percentage of cocoons when exposed to a single female *Tiphia vernalis* inthe laboratory.

No. Grubs per Container	% Grubs Parasitized	% Cocoons
1	100.0 a	80.0 a
2	60.0 b	66.7 a
3	40.0 bc	83.3 a
4	25.0 c	80.0 a
5	28.0 c	85.7 a

Percentages in a column followed by the same letter are significantly different by Tukeys Test (P<0.05)

Cicada Damage to Cornus Florida

(Poster)

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Nature of Work: Periodic cicada, *Magicicada septendecim*, Brood XIX of the 13 year cycle, the largest brood of the 13-year cicadas (3,4), struck southern parts of west Kentucky and caused significant damage in nurseries and landscapes. Cornus florida, flowering dogwood, plants three to four years in the field seemed to be particularly susceptible to damage. Branches up to 24 inches long had to be removed in order to prune out the damage caused by the female cicada egg laying. In a west Kentucky nursery few genus suffered the amount of damage found on dogwood.

All dogwoods in the nursery had to be pruned. It was estimated at the time of pruning that the branches removed averaged 18" long and represented two years growth. It seemed at the time of pruning that the branches that were damaged but did not break were larger than the stems that broke causing limbs to wilt and die (flags).

Fifty stems with cicada damage that had broken over causing flags and fifty stems that had not broken but were damaged were collected. The diameter of the stems was measured at the break and at the midpoint of the damage on the unbroken stems.

Results and Discussion: There was a difference (LSD=0.02 inches) between the diameter of the stems that broke and those that were damaged but not broken. The average diameter of the damaged unbroken stems was 0.246 inches (approximately pencil diameter). The broken stems averaged 0.196 inches. While rare, branches up to 0.291 inches were found broken. No branches damaged by female cicada egg laying that were collected from dogwood in the nursery studied were larger in diameter than 0.298 inches.

Significance to Industry: The cicadas attack young vigorously growing trees (3,4). Protection efforts, physical (2) or chemical (1), for dogwoods should concentrate on protecting branches with a diameter of less than 0.298 inches. The loss of branches in that diameter range adds at least a year to the production cycle. The next major cicada outbreak to affect west Kentucky will be Brood XXIII of the 13-year cycle in 2002 (3).

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Strategy for Effective Control of a Maple Shoot Borer, *Proteoteras aesculana* Riley (Lepidopera: Tortricidae), in Red Maple

(Poster)

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Nature of Work: Young larvae probably overwinter in hollowed-out buds (1). In mid to late April, young larvae emerge and feed for a short time on new leaves, buds and shoots before tunneling into the elongating shoot (2). The shoot quickly wilts after tunneling begins. The larva continues to develop as it hollows out the shoot. It pupates and the adult moth emerges from mid-June into July. Eggs are layed on the shoots in mid summer and young larvae feed for a short time prior to overwintering.

The destruction of the terminal bud or shoot of red maple by a shoot boring caterpillar produces a forked or double leader. This damage is a major impediment to the production of high quality red maple in Tennessee. Insecticide sprays or soil applied systemic insecticides need to control the larvae before they can bore into the shoot. Unfortunately, insecticide sprays are often applied too late and are not effective.

Control Recommendations: A foliar spray of Talstar 10 WP should be applied in April when the first two pair of leaves have come out (3,4). An additional spray 5-7 days later is more likely to be needed on seedling trees due to the variability in leafing out as compared to the more uniform growth of cultivars.

Significance to Industry: More effective early season control will allow for the increased production of high quality red maple trees. The amount of labor needed to train a new single leader on damaged trees will also be minimized.

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Evaluation of Three Soil-Applied Insecticides for Root Weevil Control In Container-Grown Nursery Crops

(Poster)

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Nature of Work: Black vine weevil, *Otiorhynchus sulcatus* (Fabricius), is a widespread insect pest of nurseries throughout the United States. Plant damage is primarily caused by soil-borne larvae, which feed on roots and bore into underground plant parts (Moorhouse, 1990). Adult feeding on foliage is less damaging, but leaf notching reduces the quality and marketability of nursery crops. Damage can result from relatively few larvae. Economic threshold estimates are 3 larvae per one-year-old potted *Rhododendron* (Lalone and Clark, 1981). Typical nursery production systems favor survival of root weevil larvae (Stimmann et al., 1985), such as organic growing substrates, soil moisture and temperature management that favors larvae survival, and close proximity of susceptible host plants. There are over 100 susceptible plant species, including: azaleas, rhododendrons, primrose, heathers, kinnikinnik, maples, salal, spruce, viburnum, strawberry, grape, roses and yews. Black vine weevil management recommendations emphasize repeated evening foliar pesticide applications targeting adult weevils (Fisher et al., 1995). The objective of this study was to determine the efficacy of soil-applied insecticides for adult black vine root weevil control in container-grown nursery crops.

Black vine weevil adults were collected from Bird's nest spruce (*Picea abies* 'Nidiformis') growing in 10-gal (25-liter) containers. Adult stages of black vine root weevil, *Otiorhynchis sulcatus*, were established in *Thuja occidentalis* 'Emerald' and *Rhododendron* 'Vulcan' growing in 1-gal. (2.5-liter) pots in May 1997. Seven root weevil adults were placed onto the soil surface of each pot. Insecticides were applied during daylight hours on 20 May 1997. Foliar treatments were applied using a manually pressurized backpack sprayer. Baits and granular treatments were applied by hand to the soil surface. For *Rhododendron*, treatments consisted of: 1) an untreated control; 2) Topcide (lamba-cyhalothrin, 1.2oz/100gal); 3) Topcide (lamda-cyhalothrin, 4.8oz/100gal); 4) Pinpoint 15G (acephate, 16.5 lb/A); 5) Pinpoint 15G (acephate, 33.0 lb/A); 6) Cryolite (sodium aluminofluoride-based bait, 30 lb/A); and 7) Gowan 1885 (sodium aluminofluoride-based bait, 30 lb/A). There were five blocks per treatment, each containing five plants. At 1 and 7 days after treatment, root weevils were collected from each container and evaluated for moribundity and mortality. Treatments 1, 3, 5, and 6 were applied to *Thuja* and evaluated 1, 3 and 8 days after treatment. Data was analyzed using Analysis of Variance. Plant species were analyzed as separate experiments.

Results and Discussion: For *Thuja*, no treatments influence root weevil mortality until three days after application (Table 1). Cryolite had the highest percentages of dead or moribund adult weevils three days after application. Eight days after application, Pinpoint and Cryolite had killed the most weevils compared to Topcide or the untreated controls.

For *Rhododendron* one day after application, the percentage of dead weevils was higher for Cryolite and Gowan 1885 compared to all other treatments (Table 2). Seven days after application, Cryolite, Gowan 1885 and the Pinpoint treatments had higher percentages of dead weevils compared to the Topcide treatments or the untreated controls.

Significance to Industry: Soil-applied insecticide provides a useful alternative to foliar cover sprays for adult root weevil control. Cryolite, Gowan 1885, and Pinpoint 15G (high rate) had the highest mortality (70% to 79%) compared to untreated or Topcide-treated plants. Pinpoint 15G and both sodium aluminofluoride bait treatments may provide an effective, viable option for adult root weevil control when pesticides cannot be applied in the evening, or when foliar cover sprays may harm nontarget organisms.

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Acknowledgements:

The authors thanks the Oregon Association of Nurserymen and the Oregon Department of Agriculture for support of this study. For technical assistance, the authors thanks: Alison Henderson, Thirza Collins, Kathy Sanford, Bonnie Coy, Sally Shaw, Sarah Andrews, and Danielle Furrer.

Table 1. Influence of soil-applied insecticides on mortality and moribundity of black vine root weevil in *Thuja occidentalis* 'Emerald.'

Days After treatment[2]	Insecticide	Application rate	Percentage Dead	Percentage Dead or Moribund
1	untreated	0	0.7 a[1]	2.4 a
	Topcide	4.8 oz/100 gal	7.9 a	14.9 a
	Pinpoint 15G	33 lbs./acre	3.3 a	7.3 a
	Cryolite	30 lbs/acre	6.9 a	13.1 a
3	untreated	0	2.6 c	5.0 d
	Topcide	4.8 oz/100 gal	8.2 b	33.3 c
	Pinpoint 15G	33 lbs./acre	13.3 b	52.1 b
	Cryolite	30 lbs/acre	18.9 a	71.3 a
8	untreated	0	17.0 c	20.0 b
	Topcide	4.8 oz/100 gal	36.3 b	76.7 a
	Pinpoint 15G	33 lbs./acre	70.6 a	88.5 a
	Cryolite	30 lbs/acre	77.6 a	91.1 a

[1] Means in columns for the same days after treatment and followed by the same letter are not significantly different; Mean seperation using LSD (5%).

Table 2. Influence of soil-applied insecticides on mortality and moribundity of black vine root weevil in Rhododendron 'Vulcan.'

Days After treatment[2]	Insecticide	Application rate	Percentage Dead	Percentage Dead or Moribund
1	untreated	0	0.0 b[1]	1.4 c
	Topcide	1.2 oz/100 gal	6.1 b	30.4 b
	Topcide	4.8 oz/100 gal	9.6 b	42.5 ab
	Pinpoint 15G	16.5 lbs./acre	5.2 b	13.3 c
	Pinpoint 15G	33 lbs./acre	7.9 b	11.9 c
	Cryolite	30 lbs/acre	22.9 a	46.3 ab
	Gowan 1885	30 lbs./acre	24.8 a	49.0 a
7	untreated	0	11.4 d	24.8 c
	Topcide	1.2 oz/100 gal	40.2 c	70.3 b
	Topcide	4.8 oz/100 gal	27.4 c	75.2 b
	Pinpoint 15G	16.5 lbs./acre	64.6 b	83.9 ab
	Pinpoint 15G	33 lbs./acre	77.8 a	90.2 a
	Cryolite	30 lbs/acre	70.3 ab	82.8 ab
	Gowan 1885	30 lbs./acre	79.3 a	83.3 ab

[1] Means in columns for the same days after treatment and followed by the same letter are not significantly different; Mean seperation using LSD (5%).