Entomology

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Evaluation of Three Insecticides for Control of the Florida Fern Caterpillar

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Index Words: Boston Fern, Florida Fern Caterpillar, *Callopistria floridensis*, *Nephrolepsis exaltata* 'Bostoniensis', Insecticides, Pest Management

Nature of Work: Boston ferns are an important greenhouse crop, especially for smaller growers in the Southeastern United States. Fortunately these plants are plagued by few significant insect pests in the greenhouse environment. Still, several insects are occasional pests of the Boston fern including aphids, mealybugs, scale insects, false spider mites, fungus gnats and shore flies. The most significant insect pest encountered in Southeastern Boston fern production is the Florida fern caterpillar (*Callopistria floridensis*). The Florida fern caterpillar damages plants with a chewing type of feeding. When infestations of the Florida fern caterpillar are not controlled, plants appear unthrifty and unmarketable due to extensive feeding. An interesting and unusual characteristic that typifies infestations of the Florida fern caterpillar is the unmistakable, sickly-sweet odor produced by feeding caterpillars. Infestations of the Florida fern caterpillar are easily detected in the greenhouse by odor alone, prior to any visual symptoms of feeding damage. Most growers rely on insecticides from either the organophosphate (e.g., acephate) or carbamate (e.g., carbaryl) insecticide classes to control this pest. While these insecticides are effective for controlling the Florida fern caterpillar, growers may wish to use other chemistries for reasons of pesticide resistance management, reduced worker re-entry interval, pesticide availability, and other issues. The purpose of this study was to compare the efficacy of several insecticides (Table 1) for control of the Florida fern caterpillar.

Two to three Florida fern caterpillars in various stages of development were placed on previously uninfested six-inch Boston ferns on August 28, 2001. Each fern was placed into a 21-inch saucer to allow for the observation of frass (an indicator of living caterpillars) and dead caterpillars. Plants were blocked so that each treatment contained at least one plant infested with an older caterpillar and one plant infested with more than two caterpillars. Plants were sprayed with their respective treatments one day following infestation with a mean treatment volume of 1.5

fl oz per plant. The experimental design was a randomized complete block with six replicates. Experimental units consisted of a single six-inch Boston fern plant. Treatments were evaluated for efficacy at 1, 3, 7 and 14 days after treatment (DAT). Statistical analyses were performed using analysis of variance and Fisher's Protected Least Significant Difference (_≤0.05).

Results and Discussion: All treatments significantly lowered Florida fern caterpillar populations compared to the water-treated control on at least one sample date (Table 1). Differences among insecticide treatments were apparent in terms of speed of response and length of efficacy. At 1 DAT, all three treatments containing Conserve, as well as those containing Orthene TT&O Spray 97and Mattch had significantly lower caterpillar populations than the water-treated control. At 1 DAT, the Confirm treatment was not significantly different from either the water-treated control or the highest rate of Conserve (22 fl oz/ 100 gal). Caterpillars near death (moribund) were rated as living. At 1 DAT, the only caterpillars found on the 22 fl oz Conserve treatment were moribund; treating these caterpillars as living resulted in the lack of differences between the Confirm and 22 fl oz Conserve treatments. At 3 DAT, only the treatment containing Confirm did not have significantly lower caterpillar populations than the water-treated control; however, the caterpillars found in the Confirm treatment at 3 DAT were moribund. There were no differences among treatments containing Conserve, Orthene TT&O Spray 97and Mattch. At 7 DAT, treatments containing Conserve, Orthene TT&O, Confirm and Mattch had significantly lower caterpillar populations than the water-treated control and there were no differences among the efficacious treatments. By the final observation, 14 DAT, treatment protection was breaking down in the Confirm and Mattch treatments; thus, treatments containing these active ingredients did not have significantly lower caterpillar populations than the water-treated control. Treatments containing Conserve and Orthene TT&O did have significantly lower caterpillar populations than the water-treated control and were statistically indistinguishable from one another. Test plants were surrounded by untreated, infested ferns, providing a constant source of egg laying adult female moths on test plants. Therefore, this test was conducted under extremely high pest populations.

Significance to the Industry: For growers of Boston ferns in the Southeast, the most significant insect pest is the Florida fern caterpillar. This trial demonstrates that there are several efficacious insecticides in addition to traditional chemistries (i.e., acephate (e.g., Orthene) and carbaryl (e.g., Sevin)) for controlling the Florida fern caterpillar. These chemistries, Conserve, Confirm or Mattch can be effectively used by growers for reasons of pesticide resistance management, reduced worker re-entry interval, pesticide availability, or as the pesticide of first choice for control of the Florida fern caterpillar.

Table 1. Mean number of alive Florida fern caterpillars recovered from each plant on different sample dates.

Treatments	Active Ingredient	Chemical Class	Rate[x]	1 DAT	3 DAT	7 DAT	14 DAT
Water-treated	—		—	1.3 a[z]	1.0 a	1.5 a	4.8 a
Conserve	spinosad	biological	6 fl oz	0.0 c	0.0 b	0.0 b	1.0 b
Conserve	spinosad	biological	11 fl oz	0.2 c	0.0 b	0.0 b	0.5 b
Conserve	spinosad	biological	22 fl oz	0.3 bc	0.0 b	0.0 b	0.2 b
Orthene TT&O Spray	acephate	organophosphate	8 oz	0.2 c	0.0 b	0.0 b	0.0 b
Confirm	tebufenozide	hydrazine (IGR)	8.3 fl oz	1.0 ba	0.5 ba	0.0 b	4.8 a
Mattch	*B.t.* delta-endotoxins	biological	128 fl oz	0.2 c	0.3 b	0.0 b	4.2 a

[x]Amount of formulated product per 100 gal
[z]Treatments followed by the same letter are not significantly different. Means were separated using Fisher's Protected Least Significant Difference, _≤0.05.

Aquatic Plant Pest Identification and Management

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Index Words: Water Garden, Control, Production

Nature of Work: Since 1973 the National Gardening Association has contracted with the Gallup Organization, Inc. to conduct annual comprehensive market research surveys (2). The survey provides in-depth and up-to-date marketing information on industry trends, household participation, consumer profiles, and retail sales. Statistics from the 1998-99 National Gardening Survey estimate sales of water gardening products and services at $659 million dollars. Approximately five percent of households surveyed (5 million) participate in water gardening, spending on average $219 per year. These numbers have increased 40-60% from just five years ago, making water gardening the fastest growing segment of the gardening market.

USDA statistics from 1998 show that the nursery and greenhouse industry comprises the fastest growing segment of U.S. Agriculture (5). In 1999 the USDA – National Agricultural Statistics Service (NASS) conducted the eighth Census of Horticulture Specialties which, for the first time, included information on aquatic plants. (Results can be found at http://www.nass.usda.gov/census/.) The census is the only source of detailed production and sales data on aquatic plants at the national level. A horticultural specialty operation is defined as any place that grows and sells $10,000 dollars or more of horticultural specialty products (sod, mushrooms, cut Christmas trees, herbaceous perennials, aquatic plants). Horticultural specialty operation sales of aquatic plants totaled approximately $23.5 million dollars, of which 65% was from wholesale transactions. Ninety one percent (approximately $21.5 million dollars) of those sales were from operations that listed aquatic plants as their principal source of income (50% or more). The increasingly popular landscape trend of water gardening has placed serious demands on the horticulture industry for information, services, products, and especially plants.

Results and Discussion: Production of aquatic plants is increasing to keep up with demand, however successfully increasing production of any new group of plants can only be accomplished with good information on which to base production techniques and pest management decisions. Producers of aquatic plants are restricted in their pest management options by two key factors: production is often in greenhouses, and production often involves an aquatic ecosystem which includes fish. Chemical pest management options are very limited in both situations, but are almost nonexistent when the two are combined.

An integrated approach is essential for pest management on aquatic plants. A series of publications on aquatic plant production is being developed at Virginia Tech to provide critical information for producers. These publications will assist producers in improving quality and quantity of nursery stock by improving pest management decisions and production practices.

The first publication in the series is 'Aquatic Plant Pest Identification'. Early detection and accurate identification of pests is critical for making best management decisions and implementing control practices. A list consisting of the most common pests of aquatic plants was developed based on three key criteria: most commonly produced aquatic plants, surveys of Virginia aquatic plant producers, and pests listed in water garden literature (1,3,4). The list includes aphids, black vine weevil (*Otiorhynchus sulcatus*), caddisflies, China mark moth (*Nymphula* spp.), Japanese beetle (*Popillia japonica*), leaf beetle (*Donacia* spp.), leaf-mining midge (*Chironomus* spp.), false leaf-mining midge (*Cricotopus ornatus*), waterlily beetle (*Galerucella nymphaeae*), fungus gnats (*Bradysia* spp.), whiteflies (*Bemisia* spp., *Trialeurodes* spp.), spider mites (*Tetranychus* spp., *Oligonychus* spp.), and snails (*Limnaea stagnalis*). Forthcoming publication topics will include aquatic plant pest management, fertilizers, containers, substrates, and propagation.

Significance to Industry: Up-to-date user-friendly aquatic plant production resources are critical for this rapidly expanding segment of the nursery industry. Resources specific to aquatic plant production will help producers make better management decisions so that quality, quantity, and ultimately profit will improve. The major pests of aquatic plants have been identified and control recommendations formulated. Producing quality plants will result in less in-put to maintain those plants in the landscape, and in healthier environments.

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Evaluation of Selected Insecticides on Cannas for Prevention of the Lesser Canna Leafroller – Part II

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Index Words: Lesser Canna Leafroller, *Geshna cannalis, Canna generalis*, Insecticide Evaluations

Nature of Work: The lesser canna leafroller, *Geshna cannalis* (Quaintance) is a small moth native to Central and tropical South America and present throughout the southeastern United States. The caterpillar stage of this moth is one of the most damaging insect pests on cannas in Alabama. Mild winters favor this tropical pest. Plant damage is due to the caterpillar fastening leaf edges of new growth together before they unfurl, producing growth deformation and reduction or failure to bloom. Feeding damage, which primarily occurs on the upper leaf surface, contributes to the unsightly tattered appearance of infested cannas. For the second year an evaluation was undertaken at the Ornamental Horticulture Research Center, Mobile, AL with the objective of finding insecticides to prevent damage to cannas.

Tropicanna ™ cannas (*Canna generalis* L.H. Bailey), provided by Plant Development Services Inc. (17325 County Rd. 68, Loxley, AL 36551) were divided and potted in full gallon plastic containers on April 13, 2001. The medium used was 3:1 milled pine bark: shredded peat moss amended with 6 pounds dolomitic lime, 2 pounds gypsum, and 14 pounds Scott's Osmocote 15-9-12 Plus per cubic yard. Before each experiment, any suspected infestation or damage was removed by pruning. Six single plant replicates were treated and then arranged in a completely randomized design. All treatments (Table 1) were foliar sprays applied at 1 or 2 week intervals except the Pinpoint 15G granular treatments that were applied at 2-week intervals. Foliar sprays covered all leaf surfaces including the whorls to the point of run-off with a CO_2 sprayer at 40 psi. Pinpoint 15G was applied to the medium surface and irrigated with approximately 250 ml of water per pot. Evaluations were conducted every two weeks by examining the plants and determining percent infested whorls. Data were analyzed with an analysis of variance with mean separations performed using Duncan's Multiple Range Test ($p \leq 0.05$).

Results and Discussion: Throughout the study 6 (1 pretreatment and 5 post treatment) counts were taken. Three of the 6 observations were selected and presented as reflective of the entire study (Table 1). Decathlon 20WP and Talstar N at both spray intervals as well as weekly sprays of Orthene TTO 97 provided good protection. With one exception, less than 10% of the whorls were infested. Orthene TTO 97 (2-week interval), and weekly sprays of Sevin 80 WP and DuraGuard ME also provided low infestions (3-33%). Protection from DuraGuard ME (2-week interval) was delayed until the June 14 observation (data partly shown). Azatin XL and Pinpoint 15G were not effective. No phytotoxicity was observed.

Significance for Industry: This study was carried out under maximum pest pressure. Untreated plants with *Geshna cannalis* were randomly distributed throughout the test plot providing a constant source of pest infestation. The presence of infested plants that are left untreated within treated areas is different from typical nursery operations where all plants in an area get treated, therefore lowering pest pressure. In 2001, 2 synthetic pyrethroids, Decathlon 20WP and Talstar N at both spray intervals, as well as weekly applications of Orthene TTO 97, gave good protection overall. Orthene TTO 97 every 2 weeks, Sevin 80WP weekly, and DuraGuard ME also provided protection.

Table 1. The Effect of Labeled Insecticides on Prevention of Canna Leafroller.

Treatment	Rate/ 100 Gallons	Interval[1] (weeks)	% Whorls Infested[2]		
			May 17	June 14	July 12
Orthene TTO 97	12 oz	1	0 e	0 d	0 d
Orthene TTO 97	12 oz	2	33 cde	17 bcd	15 abcd
Pinpoint 15G	2g/pot	2	58 abcd	42 abc	26 abc
Pinpoint 15G	3g/pot	2	45 bcde	29 bcd	38 a
Sevin 80WP	0.5 lb	1	25 cde	18 bcd	3 cd
Sevin 80WP	0.5 lb	2	86 ab	51 ab	13 bcd
Azatin XL	16 fl oz	1	58 abcd	35 bcd	33 ab
Azatin XL	16 fl oz	2	67 abc	43 abc	16 abcd
Decathlon 20WP	1.3 fl oz	1	0 e	0 d	0 d
Decathlon 20WP	1.3 fl oz	2	17 de	4 d	0 d
DuraGuard ME	25 fl oz	1	17 de	17 bcd	8 cd
DuraGuard ME	25 fl oz	2	67 abc	0 d	8 cd
Talstar N	20 fl oz	1	0 e	8 cd	0 d
Talstar N	20 fl oz	2	0 e	0 d	0 d
Untreated	—	—	100 a	72 a	22 abcd

[1]Treatments applied 5/3, 5/10, 5/17, 5/24, 5/30, 6/7, 6/14, 6/20, 6/28, and 7/5 as weekly sprays, and on 5/3, 5/17, 5/30, 6/14, and 6/28 as biweekly sprays.

[2] Means followed by the same letter within columns are not significantly different (Duncan's Multiple Range Test, a = 0.05).

IR-4 Nursery Crop Pest Control Research During 2001

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Index Words: Pesticides, Biopesticides, Label,Registration, Insecticides, Fungicides, Herbicides, Nematicides, Plant Growth Regulators, PGR's.

Nature of Work: Research trials are conducted by State, Federal and independent cooperators within the IR-4 ornamentals program. This program was established in 1977 to develop data for use in obtaining national label registrations of pesticides and biopesticides for nursery, floral crop, forestry, Christmas tree and turf production and maintenance. Data is also collected to develop national label registrations for tissue culture, the commercial landscape and the interior plant scape industries. Many of the 2001 trials were evaluated for phytotoxicity, but some efficacy trials were conducted. A total of 109 protocols were developed including 32 fungicides, 45 herbicides, 24 insecticides, one nematicide and eight plant growth regulators. These protocols were developed to collect accurate, uniform data which is required for national label registration.

Of these 109 protocols 62 were used in the 2001 trials. These include 23 fungicides, 19 herbicides, 13 insecticides, one nematicide and six plant growth regulators. A total of 776 trials were conducted by 35 state, federal and private researchers at 26 sites in 18 states. (A trial consists of a single pesticide and a single plant taxa or pest species.)

Results and Discussion:

The following twenty three (23) fungicides were evaluated:

Acibenzolar (Actigard 50WP)
Azoxystrobin (Heritage 50)
Bacillus subtilis (Serenade)
BAS 500 (Insignia 20 WG)
Chlorine Dioxide (Aseptrol)
Chlorothalonil + Thiophanate Methyl (Spectro 90 WDG)
Copper Hydroxide + Mancozeb (Junction)
Copper Salts-Fatty + Rosin Acids (Camelot)
Cyprodinil + Fludioxonil (Switch)
Dimethomorph (Ardent 50WP)
Dimethomorph + Mancozeb (Stature 69 WP)
Fenbuconazole (Enable 2F)
Fenhexamide (Decree 50 WDG)
Fludioxonil (Medallion 50)
Flutolanil (Contrast 70 WSP)
Gliocladium catenulatum (Primastop)
Mancozeb + Zoxamide (Gavel 75 DF)
Milsana Bioprotectant
Myclobutanil (Eagle 20EW)
Neem Oil Extract (Triact 70 EC)
Potassium Bicarbonate (First Step)
Streptomyces griseoviridis (Mycostop)
Trifloxystrobin (Compass 50W)

The following nineteen (19) herbicides were evaluated:

Bentazon (Basagran T/O)
Clethodim (Envoy)
Clopyralid (Stinger)
Dichlobenil (Casoron 4G)
Dithiopyr (Dimension 1EC)
Flumioxazin (Valor G, WDG)
Halosulfuron (Manage 75 WDG)
Imazapic (Plateau)
Isoxaben + Trifluralin (Snapshot 2.5 TG)
S-Metolachlor (Pennant)
Napropamide (Devrinol 2G)
Oxadiazon + Pendimethalin (Kansel Plus)
Oxadiazon + Prodiamine (Regalstar G)
Oxyfluorfen + Oryzalin (Rout 3G)
Oxyfluorfen + Oxydiazon (Regal -0-0)
Oxyfluorfen + Pendimethalin (OH II)
Pendimethalin (Pendulum 60 WDG)
Prodiamine (Barricade 65)
Trifluralin (Trifluralin 5G)

The following thirteen (13) insecticides were evaluated:

Abamectin - Avermectin (Avid)
Acephate (Orthene TTO)
Buprofezin (Applaud)
Carbaryl (Sevin)
Chloropyrifos (Dursban 50 W)
Clofentezine (Ovation)
Dimethoate (Dimethoate 4EC)
Fenpyroximate (Akari 5SC)
Halofenozide (Mach 2)
Pyridaben (Sanmite)
Pyriproxyfen (Distance)
Tefluthrin (Fireban 1.5G)
Trichlorfon (Dylox 80SP)

The following nematicide was evaluated:

Sodium tetrathiocarbonate (Enzone)

The following six (6) plant growth regulators and combinations were evaluated:

6-Benzyl Adenine (BAP-10)
Chlormequat (Cycocel)
Chlormequat (Cycocel) + Daminozide (B-Nine)
Daminozide (B-Nine)
Paclobutrazol (Bonzi)
Uniconazole (Sumagic)

The IR-4 Ornamental Research Program led to 296 new label registrations in 2001 for use by the ornamental industry (Table 1).

Significance to Industry: Since the IR-4 Ornamental Research Program was initiated over 9400 National label registrations have been obtained using IR-4 generated data.

Literature Cited:

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2. IR-4 2001. IR-4 Annual Report. Cook College, Rutgers The State University of New Jersey, New Brunswick, NJ: 52pp.

3. IR-4 2001. "Commercially Grown Floral, Forestry, Nursery and Turf Crops". IR-4 Minor Use Report Card. 2002 Update 29pp.

Table 1. 2001 pesticide registrations supported by IR-4 data.

Acephate (Orthene, turf, tree & ornamental spray)
English Daisy (*Bellis perennis*)

Azoxystrobin (*Heritage 50*)
Douglas Fir (*Pseudotsuga*)
Fir (*Abies*)

Bendiocarb (*Turcam* 2.5 G)
Azalea (*Rhododendron*)
Begonia
Carnation (*Dianthus*)
Hemlock (*Tsuga*)
Holly (*Ilex*)
Laurel (*Kalmia*)
Rhododendron
Spruce (*Picea*)
Winged euonymus (*Euonymus*)

Bordeaux mixture
Aspen (*Populus*)
Cherry (Non-bearing) (*Prunus*)
Crabapple (Non-bearing) (*Malus*)
Flowering Dogwood (*Cornus florida*)
Kousa Dogwood (*Cornus kousa*)
Lilac (*Syringa*)
Red Maple (*Acer rubrum*)
Sugar Maple (*Acer saccharum*)
Pear (Non-bearing) (*Pyrus sp*)
Poplar (*Populus*)
Willow (*Salix*)

Candida oleophila (*Aspire*)
Apple (Non-bearing) (*Malus*)
Azalea (*Rhododendron*)
Bunchberry (*Cornus canadensis*)
Western red cedar (*Thuja*)
Cinquefoil (*Potentilla)*
Conifer
Crocus (*Colchicum*)

Daffodil (*Narcissus*)
Douglas fir (*Pseudotsuga*)
Fir (*Abies*)
Holly (*Ilex*)
Hydrangea
Lily (*Lilium*)
Maple (*Acer*)
Rhododendron
Rose (*Rosa*)
Tulip (*Tulipa*)
Western Hemlock (*Tsuga*)

Chlorfenapyr (*Pylon*)
Chrysanthemum
New Guinea (*Impatiens*)
Rose (*Rosa*)

Clethodim (*Envoy* 12.6%)
Boxwood (*Buxus*)
Bridal-wreath spirea (*Spiraea*)
Candytuft (*Iberis*)
Cinquefoil (*Potentilla)*
Creeping lilyturf (*Liriope*)
Pinks (*Dianthus*)

Clofentezine (*Ovation*)
Ageratum
Juniper (*Juniperus*)
Field Marigold (*Calendula*)
Persian Violet (*Cyclamen*)
Rose (*Rosa*)
Snapdragon (*Antirrhinum*)

Copper Hydroxide (*Kocide*)
Maple (*Acer*)
Pine (*Pinus*)
Zinnia

Copper Sulphate Pentahydrate (*Phyton* 27)
Gloxinia (*Sinningia*)
Ladies Eardrops (*Fuschia*)
Mugo Pine (*Pinus mugo*)
Rose periwinkle (*Catharanthus*)
Snapdragon (*Antirrhinum*)

Cyromazine (*Citation* 75 WP)
Carnation (*Dianthus*)
Geranium (*Pelargonium*)

DCNA (*Dicloran*)
Douglas Fir (*Pseudotsuga*)
Redwood (*Sequoia*)

Dithiopyr (*Dimension EC*)
Azalea (*Rhododendron*)
Black-Eyed Susan (*Rudbeckia*)
Blanket flower (*Gaillardia*)
Camellia
Candytuft (*Iberis*)
Leyland Cypress (*Cupressocyparis*)
Scarlet Sage (*Salvia*)
Sprengeri Fern (*Asparagus*)
Red Maple (*Acer*)
Southern live oak (*Quercus*)

Extract of Neem Oil (*Triact 70 EC*)
Rose (*Rosa*)

Fenpropathrin (*Tame 2.4 E*)
Azalea (*Rhododendron*)

Fludioxonil (*Medallion*)
Western Red Cedar (*Thuja*)
Douglas Fir (*Pseudotsuga*)
Fir (*Abies*)

Mancozeb (*Protect T/O*)
Flowering Quince (*Chaenomeles*)

Mancozeb + Zoxamide (*Gavel 75 DF*)
Balsam (*Impatiens*)
Camellia
Chrysanthemum
Geranium
Red Maple (*Acer rubrum*)
Pansy (*Viola*)
Red Pine (*Pinus resinosa*)
Scotch Pine (*Pinus sylvestris*)
White Pine (*Pinus Strobis*)
Rose (*Rosa*)

Myclobutanil (*Eagle 20 EW*)

Bee Balm *(Monarda*)

Oryzalin (*Surflan AS*)

Blanket flower (*Gaillardia*)
Chrysanthemum
Leyland Cypress (*Cupressocyparis*)
Foxglove (*Digitalis*)
Holly (*Ilex*)
Leopards-Bane (*Doronicum*)
Lilac (*Syringa*)
Star Magnolia (*Magnolia*)
Montauk Daisy (*Chrysanthem Keibels*)
Ornamental cabbage (*Brassica*)
Pampas Grass (*Cortaderia*)
Pinks (*Dianthus*)
Shasta Daisy (*Chrysanthemum x superbum*)
Speedwell (*Veronica*)
Statice (*Limonium*)
Stonecrop (*Sedum*)
Sweetgum (*Liquidambar*)
Tickseed (*Coreopsis*)
Treasure Flower (*Gazania*)
Yarrow (*Achillea*)

Oxadiazon (*Chipco Ronstar G*)

Treasure Flower (*Gazania*)

Oxyfluorfen (*Goal T/O EC*)

Ash (*Fraxinus*)
White Ash (*Fraxinus americana*)
Birch (*Betula*)
River Birch (*Betula nigra*)
Crape Myrtle (*Lagerstroemia*)
Flowering Dogwood (*Cornus florida*)
Maple (*Acer*)
Red Maple (*Acer rubrum*)
Sugar Maple (*Acer saccharum*)
Oak (*Quercus*)
Eastern Red Bud (*Cercis*)
Sweetgum (*Liquidambar*)
Tulip Tree (*Liriodendron*)
Walnut (Non-bearing) (*Juglans*)

Oxyfluorfen + Oryzalin (*Rout 3G*)

Rhododendron

Oxyfluorfen + Pendimethalin (*Kansel Plus*)

Andorra Broom (*Cytisus*)
Camellia
Geranium (*Geranium*)
Jasmine (*Jasminum*)
Oak (*Quercus*)
Southern Live Oak (*Quercus virginiana*)
Eastern Red Bud (*Cercis*)
Viburnum

Pendimethalin (*Pendulum 60 WDG*)

Abelia
Andromeda (*Pieris*)
Arborvitae (*Thuja*)
Arrowwood (*Viburnum*)
Birch (*Betula*)
Boxwood (*Buxus*)
Camellia
Canna
Cotoneaster
False Cypress (*Chamaecyparis*)
Fire Thorn (*Pyracantha*)
Flowering Dogwood (*Cornus florida*)
Geranium (*Geranium*)
Golden bells (*Forsythia*)
Heavenly Bamboo (*Nandina*)
Indian Hawthorn (*Raphiolepis*)
Japanese barberry (*Berberis*)
Cape Jasmine (*Gardenia*)
Jasmine (*Jasminum*)
Lily (*Lilium*)
Madwort (*Alyssum*)
Mallow (*Hibiscus*)
Mexican Fan Palm (*Washingtonia*)
Oleander (*Nerium*)
Oregon Grape (*Mahonia*)
Pygmy Date Palm (*Phoenix*)
Southern Yew (*Podocarpus*)
Spruce (*Picea*)
Stonecrop (*Sedum*)
Weigela
Xylosma
Yew (*Taxus*)

Permethrin (*Astro*)

African Violet (*Saintpaulia*)
Azalea (*Rhododendron*)
Buttercup (*Ranunuculus*)

Potassium Bicarbonate (*First Step*)

Japanese Spurge (*Pachysandra*)
Austrian Pine (*Pinus nigra*)
Japanese black Pine (*Pinus thunbergiana*)
Scotch Pine (*Pinus sylvestris*)

Prodiamine (*Barricade 65 WG*)

Azalea (*Rhodendron*)
Formosa Azalea (*Rhododendron*)
Hottentot fig (*Carpobrotus*)
Jasmine (*Jasminum*)
Lily of the Nile (*Agapanthus*)
Pampas Grass (*Cortaderia*)
Photinia

Pyridaben (*Sanmite*)

Bulbous Iris (*Iris xiphium*)
Cardinal Flower (*Lobelia*)
Cinquefoil (*Potentilla)*
Spruce (*Picea*)
Winged euonymus (*Euonymus alata*)

Pyriproxyfen (*Distance*)

Chrysanthemum
Coleus
Leatherleaf fig (*Ficus*)
Pothos (*Epipremnum*)
Yew (*Taxus*)

Tefluthrin (*Fireban 1.5 G*)

Azalea (*Rhododendron*)
Begonia
Camellia
Crape Myrtle (*Lagerstroemia*)
English Ivy (*Hedera*)
False spirea (*Astilbe*)
Chinese Holly (*Ilex cornuta*)
Japanese Holly (*Ilex crenata*)
Hydrangea
Japanese Hemlock (*Tsuga sieboldii*)

Juniper (*Juniperus*)
Plantain Lily (*Hosta*)
Pinks (*Dianthus*)
Purple leaf wintercreeper (*Euonymus radicans*)
Rhododendron
Spruce (*Picea*)
Yew (*Taxus*)

Triadimefon (*Bayleton*)
Begonia

Trifloxystrobin (*Compass 50 W*)
Bottle Brush (*Callistemon*)

Moth Fly and Fungus Gnat Pest Management on Potted Roses

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Index Words: *Psychoda, Bradysia, Steinernema,* Bti, Cyfluthrin, Pyriproxyfen

Nature of Work: Moth flies (*Psychoda* sp.) and fungus gnats (*Bradysia* sp.) are nuisance pests of commercially grown potted roses. Large number of adults emerging from plants may cause shipment rejection by potential buyers leading to significant economic loss. Several options are currently available for control of fungus gnats in greenhouses and nurseries but biological and chemical control of moth flies has not been investigated (1). Based on the above, a field trial was conducted at a grower operation in North East Texas to evaluate efficacy of biological and chemical control tools in reducing moth fly and fungus gnat adult emergence.

Rose plants used in the trial were standard garden varieties, potted in composted pine bark-sand mix (9:1) in 2 gallon containers and grown on uncovered concrete pads. The potting mix used had been treated with Talstar" T&O (Bifenthrin) granular insecticide at a rate of 2.8 lb/yd^3 to comply with USDA Imported Fire Ant Quarantine Certification requirements. Plants were arranged in beds of 376 pots (47 rows of 8 plants). Beds were separated from each other by approximately 2 feet. Treatments were assigned to beds in a completely randomized block design with four replicates for a total of 1,504 plants per treatment (376 plants _ 4 replicates).

The test was conducted three weeks before the scheduled shipping date and treatments were made using standard application equipment. Treatments were single applications of: 1) no insecticide (control), 2) Gnatrol" (*Bacillus thuringiensis* var. *israelensis*) at 60 oz product/100 gal, 3) Distance" (Pyriproxyfen) at 8 fl oz product/100 gal, 4) Decathlon (Cyfluthrin) at 1.9 oz product/100 gal plus Insecticidal Soap" at 1% v/v, and 5) *Steinernema feltiae* nematodes at 25 mill infective juveniles/1,500 ft^2. The insecticidal soap was added to Decathlon" to increase penetration into potting media. All treatments except Decathlon" were applied as soil drenches in a 0.5 pint volume/pot (~25 gal/bed). Decathlon" was applied as a heavy spray in a total volume of 8 gal/bed.

Adult fly emergence was monitored using un-baited Pherocon“ AM yellow sticky traps (Trece Inc. Salinas, CA) cut into strips measuring 3 _ 11 in (width _ length). Traps were placed sticky-side down at about 2 in from the soil surface on 10 haphazardly selected pots per bed (200 traps total). Traps were secured to the base of the plants using 14 in (length) wire ties. Placement of the strips sticky-side down was done to trap adults as they emerged from the potting media. Traps were set up one day after treatment and replaced once 7 days later. Emergence data were collected by counting adult flies trapped on the sticky material.

Efficacy was assessed by comparing treatment effects using analysis of variance with the help of JMP“ statistical software (version 4.0.4; SAS Institute Inc., Cary, NC). Whenever significant treatment effects were found, means were compared using student’s t-tests. Analyses were done separately for each pest species and for each of the two sampling periods.

Results and Discussion: Initial observations indicated the number of moth flies on plants was extremely high. A total of 13,871 moth flies were caught during the first week. A significant treatment effect was found for the number of moth flies caught on traps during the first week ($F_{4, 192} = 2.4$; $P < 0.05$) and second week ($F_{4, 143} = 4.5$; $P < 0.05$). Traps on Gnatrol“ treated plants caught 30% fewer moth flies ($P < 0.05$) than those on untreated plants during the first week, but no other treatment significantly reduced the number of moth flies relative to the control (Figure 1). The number of moth flies caught on untreated plants declined from 77.3 ± 8.4 (mean ± SEM) to 12.4 ± 1.7 from the first to the second week. Traps on plants treated with Decathlon“ plus insecticidal soap caught significantly higher numbers of moth flies ($P < 0.05$) than traps on untreated plants during the second week (18.4 ± 3.0 vs. 12.4 ± 1.7; Figure 1). No other treatment showed differences in the number of moth flies relative to the control.

The number of fungus gnat adults caught on traps during the first week (2,672) was 80% lower than the number of moth flies caught during the same period. A significant treatment effect was found for the number of fungus gnats caught on traps during the first week ($F_{4, 192} = 15.3$; $P < 0.001$) and second week ($F_{4, 143} = 5.0$; $P < 0.001$). Traps placed on treated plants caught lower numbers of fungus gnats than those on untreated plants ($P < 0.05$), except for traps on Decathlon treated plants which caught significantly higher numbers of gnats (Figure 2). Distance“, Gnatrol“ and *S. feltiae* showed similar effects and had 34% - 50% fewer fungus gnats than untreated plants (Figure 2). During the second week, Decathlon“ treated plants had higher numbers of fungus gnats ($P < 0.05$) than the untreated and those treated with Gnatrol“ or Distance“, but no other differences were observed.

The tested products were mostly ineffective at reducing moth fly adult emergence to acceptable levels. A single application of the parasitic nematode *S. feltiae* had similar effects on fungus gnats as Gnatrol“ or Distance“ one week after treatment, but none of the products showed control during the second week. Higher numbers of flies caught in Decathlon“ treated plants may be due to behavioral effects on adult flies, but may also be due to negative effects of this product or the insecticidal soap on natural enemies of larvae in the potting mix. Overall reduction in trap captures of both flies during the second week may have been due to higher temperatures and dryer conditions experienced during that period.

Significance to Industry: Under heavy infestations, the chemical and biological control products tested did not provide satisfactory control of moth flies or fungus gnats prior to shipment. Granular Talstar“ applied against fire ants did not reduce trap captures, and thus did not provide fly control. Cultural control practices like sanitation, good drainage and proper irrigation need to be in place to keep populations at bay through the season. Additional products and application frequencies need to be tested for control of moth flies.

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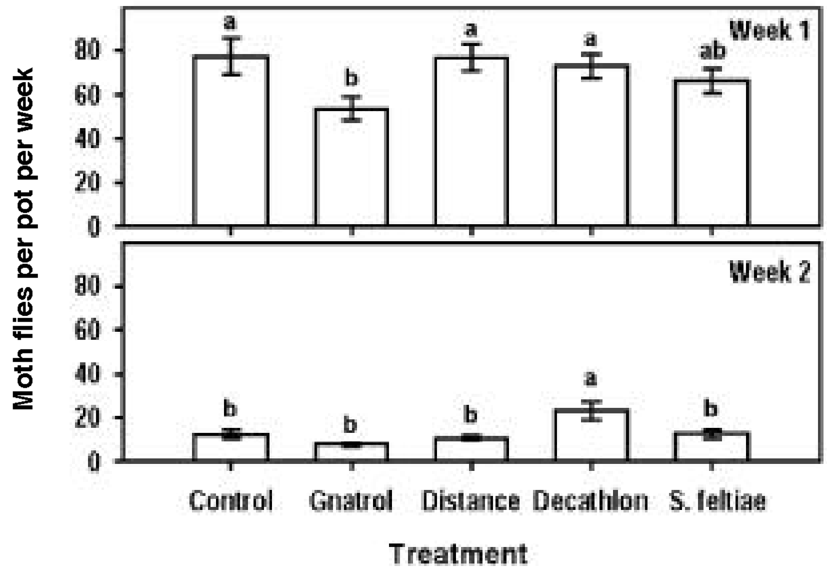

Figure 1. Average number of moth fly adults caught in sticky traps. Bars with different letters are significantly different (P < 0.05). Error bars are standard error of the mean (n=40 and 30 for week one and two, respectively).

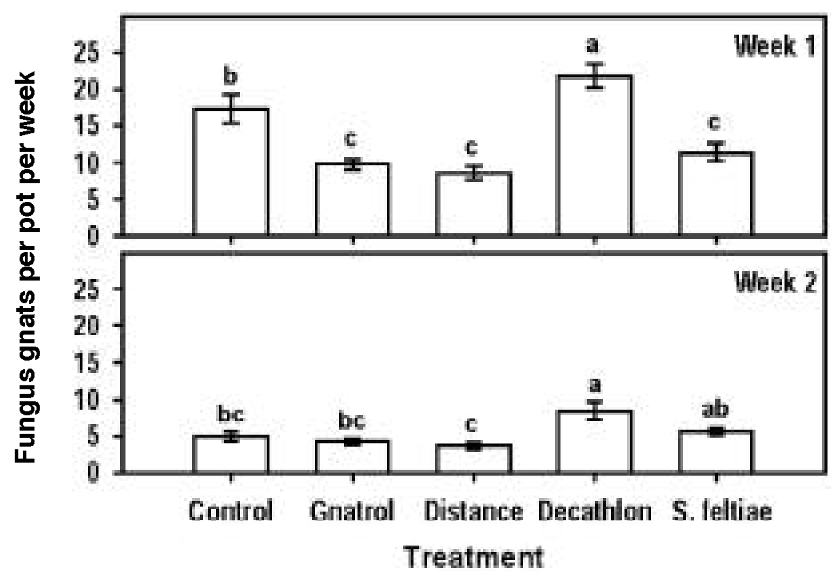

Figure 2. Average number of fungus gnat adults caught in sticky traps. Bars with different letters are significantly different (P < 0.05). Error bars are standard error of the mean (n=40 and 30 for week one and two, respectively).

Survivorship and Growth of Japanese Beetle Larvae on Common Nursery Weeds

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Index Words: Integrated Pest Management, Nursery Production, Polyphagy, *Popillia Japonica* Newman, Scarabaeidae, White Grubs.

Nature of Work: The Japanese beetle (JB), *Popillia japonica* Newman, is a non-native, polyphagous pest. Since the beetle was introduced ~1911, the reported host list for adult beetles has grown to include more than 300 species of ornamental and field crop plants as well as many weed species (3). Studies suggest that adult JB are attracted to a larger diversity of plants than are acceptable as hosts (5). Larvae are also polyphagous, but feeding injury is less apparent than that of adults. The host range of larvae is generally less resolved (1, 3, 5). Larval populations are typically aggregated and tend to occur in greatest densities near plants that have attracted aggregated adult feeding (2). At harvest, JB larvae in nursery production fields may be forced to shift food resources to co-existing weed species. Weedy nursery fields supported ten times as many JB larvae as weed-free fields (8). However, densities of 180 to 240 larvae per m^2 did not reduce the growth of many weeds and coarsely rooted grasses (7). Studies have been conducted comparing the survival and development of Japanese beetle grubs among common lawn weeds, which included large crabgrass, buckhorn plantain, red clover, annual bluegrass, Kentucky bluegrass, white clover, and dandelion (1). Though similarities exist, a different complex of weeds is typically encountered in Tennessee's ornamental production systems. These potential hosts have not been investigated for suitability as Japanese beetle larval food sources. Our objective was to compare JB larval survivorship and growth on weedy plant species that were commonly encountered in Tennessee field production nurseries. In conjunction with our objective, we compared the biomass production of weeds in infested and uninfested pots.

Weed species that were selected for inclusion in this study were chosen on the basis of a review of recent weed control literature, adaptability to pot culture, personal nursery visits, and grower confirmation of commonly encountered weeds. Weed seedlings of yellow woodsorrel (*Oxalis stricta* L.), eclipta (*Eclipta alba* L.), smallflower geranium (*Geranium pusillum* L.), yellow nutsedge (*Cyperus esculentus* L.), smooth pigweed (*Amaranthus hybridus* L.), spiny sowthistle (*Sonchus asper* (L.) Hill), groundsel (*Senecio vulgaris* L.), large crabgrass (*Digitaria sanguinalis* L.), and mugwort (*Artemisia vulgaris* L.) were gathered from naturally occurring populations in and around the Nursery Production Research Facility at Morgan Farm on the University of Tennessee Agricultural Campus in Knoxville and from containers of mixed ornamental species at a local production nursery. Chamberbitter (*Phyllanthus urinaria* L.) was included because of its rapid growth and spread in one nursery site. This weed has considerable potential to become a persistant management concern. Hairy bittercress (*Cardamine hirsuta* L.), henbit (*Lamium amplexicaule* L.), and spotted spurge (*Euphorbia maculata* L.) are also common in nursery production fields. However, due to high levels of plant mortality among treatments prior to larval infestation, these plants were excluded from the study.

Seedlings were planted initially into ProMix BX (Premier Horticulture, Red Hill, PA) and held for 2 wk under ambient light and intermittent mist in a greenhouse, which allowed acclimation and root growth. Once acclimated, weed species were blocked by size and were planted into Elite 6-in. (15.2-cm) azalea pots (ITML, Bradford, Ontario). The final growing medium consisted of 4 parts sieved (4 mm opening) soil (Sequatchie, fine-loamy, siliceous, thermic, humic Hapludults, pH 5.6)/1 part medium-to-coarse sand (mined, sieved quartz sand)/1 part fine-milled Sunshine Peat Moss (Sun Gro Horticulture, Bellevue, WA) (v/v). Weeds were arranged on the greenhouse bench in a randomized complete block design with 28 treatments in 8 replicated blocks and grown for 1 wk prior to infestation. Blocks included treatments of infested and non-infested pots for each weed species, as well as larvae-infested in uniform soil and in the final growing medium without weeds. Treatments were maintained for 4 wk in the greenhouse under 70±10^{o}F (21±5^{o}C), 16:8 h (light:dark). Weeds were held under intermittent mist for the duration of the study.

White grub larvae were field collected in September 2000 and 2001 at a commercial sod farm. In both seasons, insecticide treatments of chlorpyrifos had not been made for at least 2 mo. prior to collections. All species of larvae were returned to the laboratory for positive identification. Larvae were discarded if they showed signs of cultivation injury or were not 3rd-instars. Treatments were each infested with six 3rd-instar larvae (equivalent to 329 larvae per m^2), which were used to provide a combined initial larval weight. Grubs that failed to burrow into the growing media within 2 h were replaced with pre-weighed larvae. Grubs that were removed were subsequently weighed and the combined larval weight for the treatment was adjusted.

At the conclusion of the 4-wk study, weeds and growing media were removed from the pots. Shoots were severed at the crown and roots were carefully washed free of soil. Both roots and shoots were dried and weighed. All surviving larvae were recovered and weighed. To discern differences between infested and non-infested plant root and shoot biomasses, two-sample *t*-tests ($P = 0.05$) were conducted within each weed species. For infested treatments, final larval mass and number of surviving larvae were compared among weed species. Means were separated using Fisher's least significance difference test ($P = 0.05$) in SAS (6).

Results and Discussion: The average weight of individual 3rd instar Japanese beetle larvae used to infest the pots was 0.215 ± 0.017g in 2000 and 0.189 ± 0.006 g in 2001. At infestation, larval weights did not differ among treatments. Japanese beetle white grub survivorship was comparable among treatments during 2000 and 2001. Survivorship and larval weight rankings at the conclusion of these no-choice studies, as well as soil-only and soil-mix controls, were not consistent between years (Table 1). Larval weights were greatest among the soil-only control in 2000. These larvae, and larvae in the mixed soil treatment, exceeded their initial weights, suggesting that they fed on soil organic matter. In contrast, larval weights were greatest among white grubs recovered from yellow nutsedge treatments in 2001, which ranked 10th in 2000. These differences are not readily explained. For both years, in general, root dry weights were greater among uninfested pots (Fig. 1A-D). Shoot dry masses in infested pots did not differ from those in uninfested pots (Fig. 1A,C). Root dry weights were reduced among infested pots of yellow woodsorrel and smallflower geranium treatments in 2000, indicating that the larvae consumed these plant roots (Fig. 1B). In 2001, root masses were larger and dry weights were reduced among infested mugwort, spiny sowthistle, yellow nutsedge, chamberbitter, large crabgrass, and smallflower geranium treatments (Fig. 1D). Adult JB fed zonal geranium (*Pelargonium* X *hortorum*) leaves respond with a narcotic paralysis lasting 12 to 16 hours (4). While the response of adult JB to smallflower geranium (*Geranium pusillum*) foliage has not been investigated, this common weed does not appear to be detrimental to root-feeding larvae. We attribute root mass reductions to feeding by the third-instar Japanese beetle grubs and conclude that they will feed and develop, under no-choice conditions, on several weed species that are common to Tennessee nursery fields. No strong preferences or acute toxic effects were apparent among these weeds, which supports earlier contentions that common weeds are unlikely to be acutely toxic to third-instar Japanese beetle grubs (1).

Significance to Industry: Eliminating optimal food sources for grubs in production nursery rows may contribute to limiting the rate of spread of Japanese beetles to new areas in Tennessee and other non-infested states. The role that weedy plant species serve in maintaining larval Japanese beetle populations is poorly understood, yet considerably higher populations of JB larvae have been found in soils of weedy nursery fields than among clean-tended fields. A comparison of ten weeds common to ornamental production systems confirmed that third-instar JB larvae are capable of surviving and developing on these hosts. Although none of the weeds demonstrated acute toxic effects, larvae have may limited their consumption of plant roots. Results suggest that third-instar larvae are capable of sustained survival and growth when limited to soil organic matter.

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Table 1. Numbers and weights, ranked within columns, of surviving third-instar Japanese beetle larvae kept for 1 month in soil-filled six-inch pots containing common nursery weeds or controls.

Treatment	Mean No. Surviving Larvae[z]		Mean Larval Weights (mg)	
	2000	2001	2000	2001
Soil Only	3.9 (4)	3.9 (3)	253.1 (1)	209.9 (6)
Soil Mix	3.6 (6)	3.8 (4)	221.0 (5)	196.8 (10)
Mugwort	3.9 (4)	4.0 (2)	208.3 (11)	215.7 (2)
Spiny Sowthistle	4.1 (3)	3.6 (5)	221.6 (3)	210.9 (3)
Yellow Nutsedge	4.1 (3)	3.5 (6)	209.8 (10)	223.3 (1)
Chamberbitter	3.5 (7)	3.6 (5)	221.1 (4)	179.4 (12)
Yellow Woodsorrel	3.8 (5)	3.8 (4)	210.6 (9)	198.6 (9)
Eclipta	4.4 (2)	3.8 (4)	218.0 (6)	210.7 (4)
Groundsel	3.8 (5)	3.8 (4)	215.6 (7)	193.2 (11)
Large Crabgrass	3.8 (5)	4.3 (1)	190.3 (12)	200.6 (8)
Smooth Pigweed	4.7 (1)	3.4 (7)	211.0 (8)	207.6 (7)
Smallflower Geranium	3.6 (6)	2.9 (8)	241.4 (2)	210.6 (5)

[z] Initially, six larvae were used to infest each 6-inch pot (equivalent to 329 larvae per m^2).

Values are ranked, within columns, beside survivorship and final larval weight values.

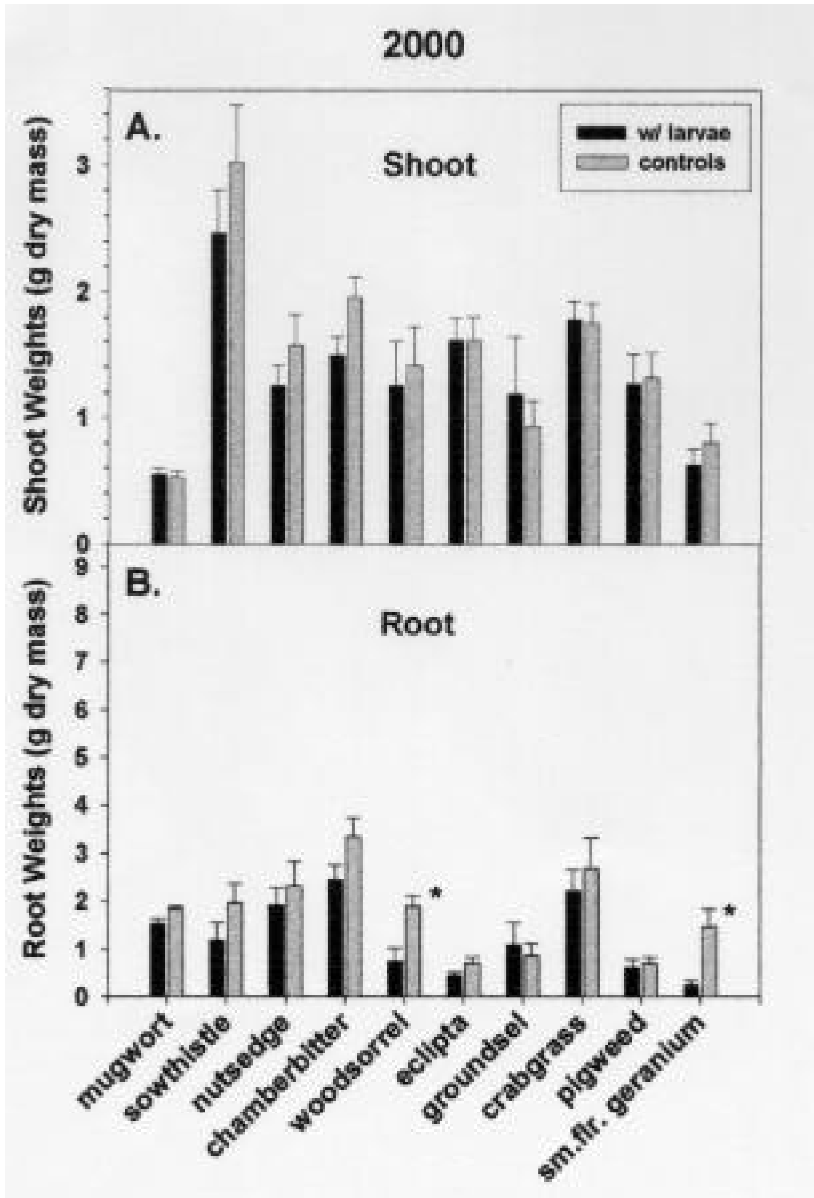

Figure 1. Mean (± SE) shoot and root dry mass of weed treatments in infested (black bars) and uninfested (gray bars) pots after 4 wk. Infested pots initially contained 6 larvae per pot (equivalent to 329 larvae per square meter). Asterisks indicate differences, based on two-sample *t*-tests within a treatment, between infested and uninfested control pots ($P < 0.05$).

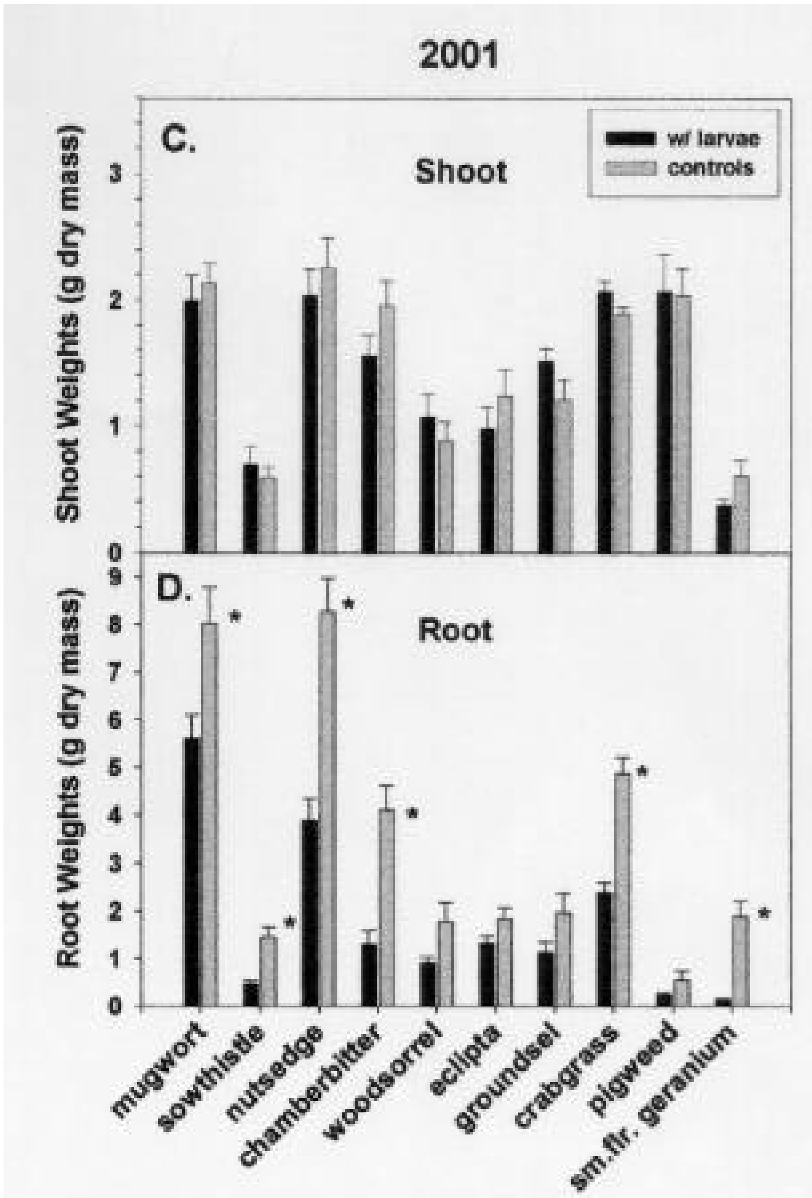

Figure 1. (continued from previous page)

Pheromone and Trap Color Influence Clearwing Borer Collection in East Tennessee

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Index Words: Growing Degree-Days, Integrated Pest Management, Lepidoptera, Sesiidae, Visual Orientation.

Nature of Work: Woody plants, especially trees, are enormously valuable once they are established in urban environments. In 1990, the value of the urban forest was estimated between $18 and 30 billion dollars (3). In addition to urban street trees, an estimated 600 million additional trees exist around private homes lawns and in parks throughout the United States (1). Within the urban landscape, many abiotic and biotic factors can predispose ornamental plants to insect and pathogen attack.

Clearwing moths (Lepidoptera: Sesiidae) attack at least 40 plant genera in North America (5). They are significant pests in urban landscapes and ornamental plant production systems. In North America, clearwing moths are represented by more than 151 species in 19 genera (5). Clearwing moths mimic wasps in appearance and behavior. They are swift daytime flyers. Forewings of sesiids are long and narrow. The thorax is often brightly banded. Partly for these reasons, many Green Industry professionals overlook the clearwing borer as a pest. Many of the symptoms of borer damage can also be confused with unrelated biotic and abiotic plant stresses (3).

Different species of clearwing moths are known to prefer slightly different pheromone chemical ratios in their long-range mating attraction. Attraction to pheromones is primarily an olfactory response. Olfactory cues are utilized for long-range attraction, but short-range visual cues may also contribute to orientation and mating by the male clearwing (5). To investigate the hypothesis that color and olfactory cues influence male clearwing attraction, a preliminary field study was initiated in March 2002 with the objective to evaluate clearwing borer monitoring methods and trapping techniques.

Experimental treatments included trap orientation, color, and pheromone blends in conjunction with Multipher-1 (Great Lakes IPM, Vestaburg, MI) style traps. Growing Degree-Days (GDD) were calculated from mean daily temperatures, which were provided for the Tennessee Tri-Cities area by the National Weather Service Forecast Office in Morristown, TN (2). GDD are expected to provide a more efficient tool for targeting the pests by monitoring than reliance on traditional calendar-spray method for managing the seasonal damage of clearwing moths. Six sites were selected ranging from open fields, transitional (grass to deciduous forest) and densely shaded locations. Each site received three color treatments: white with green top, black, or green Multipher-1 traps. One trap was left in it's commercially-available state: a white plastic bucket with a light green top, while green and black traps were created by lightly sanding and spraying the traps with Painter's Touch latex paint (Rust-Oleum, Corp., Vernon Hills, IL). A triangular metal frame was attached to a steel fence post and elevated to 1.5 meters. A single trap (one of each color treatment) was mounted on each point on the triangular frame 50cm apart. The triangular arrangement allowed the greatest likelihood of an even blend of the pheromone plume. At each site replicate, all three trap colors received either Clearwing Borer Complex blend (sites 1, 2, and 3) or Dogwood Borer Complex blend (sites 4, 5, and 6). Sites were considered replicates (3 total replicates) consisting of one pheromone-baited trap-group of green, white, and black colored traps on the triangular frame. Pheromone blends were provided by Great Lakes IPM, Inc. Vaportape (10% DDVP) toxicant insecticide tape (Hercon Environmental, Emigsville, PA) was hung inside each trap to provide quick knockdown of the fragile male moths. Traps were set approximately two weeks before the earliest reported emergence of clearwing borers and were placed in open areas with an unobstructed field-of-view. The traps were checked on three or four day intervals. Growing degree-days were calculated for the duration of the study to provide cumulative degree-day values. Captured clearwing borers were tallied by the trap color in which they were collected. Initial counts were based on field identifications. *Synanthedon* spp. moths were returned to the lab and stored until accurate species identifications could be made.

Results and Discussion: The study we report is a modification of earlier studies that investigated visual cues for trapping clearwing borers (6) and seasonal trap catch results (4). This prior research indicated that dark-colored traps, like black, brown, or green, attracted more male clearwing moths than white traps (6). In contrast, after the first four months of trapping in our study, more borers were collected in the commercially available, white-and-green-topped Multipher-1 traps than either black- or green-painted traps (Fig. 1). The current study also provides a record of lilac borer (*Podosesia syringae*) (Harris) and *Synanthedon* spp. activity based on GDD temperature accumulations (Figs. 2 and 3). First flight activity of *Synanthedon* spp. occurred around 273 GDD and initially peaked at 361 GDD. A secondary peak of activity was observed at 1127

GDD. First flight activity of *Podosesia syringae* (Harris) occurred at 219 GDD and peaking at 361 GDD. Sequential activity peaks occurred at 449 GDD and 626 GDD and rapidly decreased thereafter. Future work will continue to track borer activity in relation to GDD, which we expect to develop as a tool for monitoring adult clearwing moths in landscape and production systems.

Significance to Industry: Clearwing moths rarely attack healthy plants. A plant in decline, however, is susceptible to attack by clearwing borers. Often, plants do not show immediate evidence that they are under stress. For the landscape or grounds maintenance professional that is contracted to keep plants healthy, monitoring pest populations can be a practical way to limit pest damage. Scouts should use monitoring tools including pheromone lures, bucket traps of proper color, and growing degree-days in addition to visual inspections of plant material. The results of this preliminary study will direct the planning of future experiments that are expected to provide a better understanding of the seasonal activity of clearwing moths in Tennessee. In turn, landscape management professionals will gain valuable tools that will increase their precision for timing control strategies, which will limit clearwing pest population growth and subsequent plant damage. Early detection and control of clearwing moths will reduce chemical dependency by properly timing applications and prevent economic and aesthetic injury to the urban landscape.

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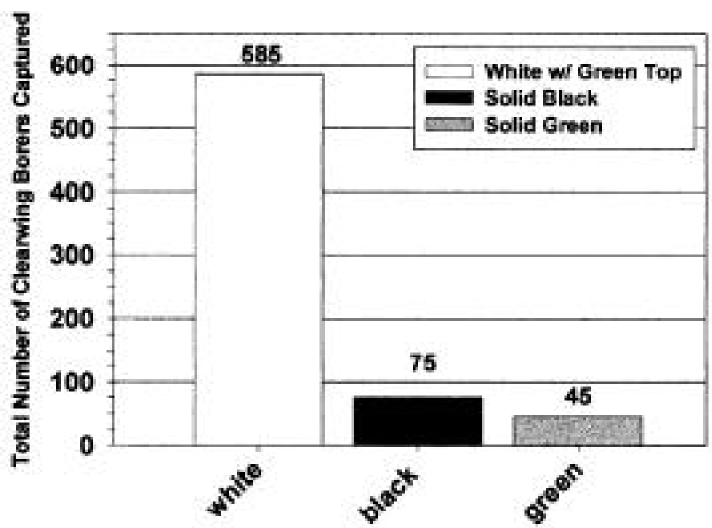

Figure 1. Trap Color Influence on Male Clearwing Borer Collection. White traps with green tops (commercially available Multipher 1 traps) caught more male clearwings than either black- or green-painted traps.

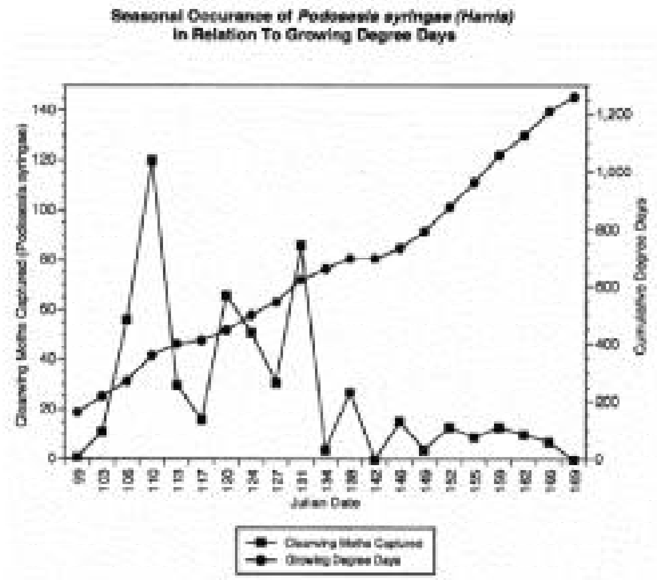

Figure 2. Results of male lilac borer (*Podosesia syringae* (Harris)) trap catches in conjunction with accumulated growing degree-days.

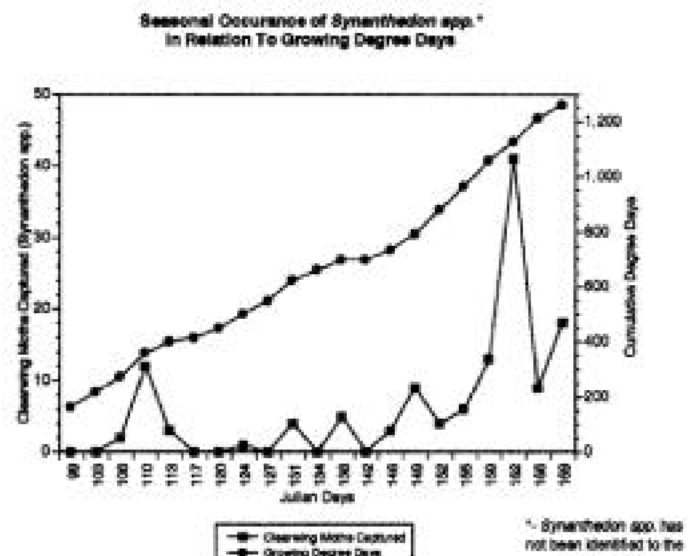

Figure 3. Results of male *Synanthedon* spp. borers caught among Multipher-1 traps baited with pheromone blends. Catch results are shown in conjunction with accumulated growing degree-days.

Managing Asian Ambrosia Beetles in Virginia

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Index Words: Asian Ambrosia Beetle, Insect Pest Management

Nature of the work: The Asian ambrosia beetle (AAB), *Xylosandrus crassiusculus* (Motshulsky), has become a pest of a wide variety of nursery and landscape trees (3). Introduced into the U.S. in 1972, it attacks apparently healthy trees and inoculates them with a fungus used to feed its larvae. As the insect bores into the trunk, sawdust and excrement (frass) are extruded from the entrance hole in the form of brittle "toothpicks." These structures are often the first indication that a tree is under attack. Heavily infested trees usually perish.

In order to devise a management plan, we used previous trap data on AAB flight periods collected in 1999 (4) and in 2000 and 2001 as a predictor of attack timing. Beetles were collected using ethanol baited Lindgren and modified Japanese beetle traps. We determined the peak flight period in Virginia to normally occur within a week of the first warm spring day, commonly between late March and mid-April.

The objective of this study was to develop a remedial treatment for trees that become infested by AAB at either a retail nursery operation or in the landscape. Our study was conducted at a Richmond, VA area retail nursery operation with AAB symptoms on newly purchased container-grown maple, ornamental cherry and pear. Two ethanol-baited traps were placed at the Richmond location on 29 April 2002 to determine AAB presence at that location. This infestation provided an opportunity to evaluate anecdotal reports of nurseries using various pesticides to extract the adult beetles from infested trees. On 8 May 2002, 16 trees were treated with a trunk application of either (permethrin 2.5%) (Astro) or chlorpyrifos 4.38% (Dursban). These insecticides, while registered for borer control, were sold as ready-to-use hose-end formulations, and not registered for use in this manner. On 14 May 2002, eight trees infested with AAB, but not previously treated, received the highest labeled Astro rate for borers (5.35 quarts per 100 gallons [equal to 0.5%]). On 1 July 2002, a new infestation in crape myrtle in a landscape setting was reported from near Richmond, and the infested tree was treated with the aforementioned Astro formulation and rate. Efficacy for all applications was measured by collection of adult beetles that had extracted themselves from the trunks of treated trees and were either on the trunk surface or on paper plates placed at the base of each tree. Collection began 5 minutes after application and continued for 30 minutes total.

Results and Discussion: The peak of AAB flight activity occurred in mid-April 2002, with the highest collection of adults on 18 April at two locations in Suffolk, VA. Peak flight in Richmond could not be determined, as the traps were deployed 11 days after the peak emergence in Suffolk. There were large numbers (>100) of AAB collected. The trunk treatments in Richmond (60 miles west) on 8 May 2002 (20 days after peak emergence) resulted in collection of AAB adults exclusively from all trees treated with either Astro or Dursban. Numbers ranged from 2-8 per tree (25 and 29 AAB from the Astro- and Dursban-treated trees, respectively). No AAB adults emerged from non-treated trees. On 14 May 2002 (26 days after peak emergence), Astro treatments resulted in AAB adults being extracted, but in lower numbers (0-2 per tree). Reports from the nursery indicated that "many" trees were alive before they were destroyed. On 1 July 2002, four AAB were collected from the crape myrtle planted in the landscape and treated with Astro. This coincided with the expected emergence of the second-generation (2).

Only AAB were collected using this method, suggesting that they are the primary invaders of trees in the nursery and landscape. Large numbers of unidentified scolytid beetles were recovered from the traps deployed in both Suffolk and Richmond. Specimens are presently being identified. The timing and quantities of these unidentified scolytids in trap collections were similar to the AAB. As the AAB attacks apparently healthy trees (but likely prefers stressed trees), merely keeping the nursery stock or landscape tree in good health through best management practices may not be sufficient protection. Trees that are attacked are often, but not always, killed. However, treating individual trees showing evidence of infestation would likely reduce tree mortality.

Significance to Industry: Nursery or landscape trees infested with evidence of AAB can be treated with the labeled rate of Astro to extract adult beetles as late as 4 weeks after initial attack. One would surmise that the best success in extraction would be obtained by treatment as close to peak flight as possible (1). Increased survival of these trees would be expected although tree damage or death due to beetle-introduced fungi may still occur.

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Interaction of an Insecticide and Entomopathogenic Nematodes for the Control of a Root Weevil

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Index Words: *Diaprepes abbreviatus*, *Heterorhabditis indica,* Entomopathogenic Nematode, Root Weevil

Nature of Work: *Diaprepes abbreviatus* (L.) (Coleoptera: Curculionidae), an introduced pest, has spread over a large area of central and south Florida where it is damaging citrus, ornamental plants, sugar cane and numerous other crops (1, 6). In addition to the damage caused by this pest, there are regulatory concerns of spreading *Diaprepes* to non-infested areas. These concerns are particularly important for the ornamental industry, which ships plants throughout the U.S. and abroad. Currently in the U.S., *D. abbreviatus* infests 22 counties in Florida and 1 county in Texas. Previous research from the citrus environment has demonstrated that bifenthrin is efficacious against neonates (newly hatched) and young larvae and that some entomopathogenic nematodes [*Heterorhabditis indica* (Poinar, Kanunakar, and David), *H. bacteriophora* (Poinar), and *Steinernema riobravae* (Cabanillas, Poinar, and Raulston)] are efficacious against young larvae (2, 3, 4, 5). Bifenthrin is currently recommended as a drench or incorporated into the potting media at a rate of 25 ppm based on the bulk density of the media. The 25 ppm rate is equivalent to the high drench rate for imported fireants. Both *H. indica* and *S. riobravae* are commercial products. However, no data exists on how efficacious bifenthrin or the nematodes are in container-grown ornamentals. Three tests were conducted to evaluate bifenthrin (Talstar Nursery Flowable) and an entomopathogenic nematode, *Heterorhabditis indica*, alone and in combination, for control of older larvae (5-9th instar) in container-grown ornamentals.

In the first test, *Diaprepes* larvae (9th instar) were exposed to two rates of Talstar (12.5 and 25 ppm = 4.4 and 8.9 fl oz per 100 gal based on the media bulk density of 739 lbs/yd^3), two rates of *H. indica* (1 and 2 billion per acre or approximately 1,400 and 2,800 per container, respectively), and all combinations of Talstar and the nematodes in 8-oz containers filled with potting media. A small carrot was provided to feed larvae. The number of live larvae in each container was evaluated daily for 6 days starting 2 days after treatment. There were 10 replications per treatment and 3 larvae per replication.

In the second test, each of three instars of *D. abbreviatus* (5, 7, and 9^{th}) were exposed to Talstar (25 ppm = 8.9 fl oz per 100 gal based on the media bulk density of 739 lbs/yd^3), *H. indica* (2 billion per acre or 25,000 per container), the combination of Talstar and nematodes, and thiamethoxam (Flagship 25WG) (17 oz per acre) in 3-gal containers planted with *Conocarpus erectus* L. (buttonwood). Treatments were applied 10 days after infesting each container with 5 larvae. There were 5 replications per treatment. Two weeks after treatment application, the test was evaluated by searching the potting media and root system for live larvae.

In the third test, 5^{th} and 9^{th} instar *D. abbreviatus* were exposed to Talstar (25 ppm = 9.3 oz per 100 gal based on the media bulk density of 772.2 lbs/yd^3), *H. indica* (9.8 billion per acre or approximately 1 million per container), and the combination of Talstar and nematodes in 45-gal containers planted with *Bucida buceras* L. (big leaf black olive). Treatments were applied 7 days after infesting each container with 15 larvae (half of each age). Approximately five weeks after treatment application, the test was evaluated by searching the potting media and root system for live larvae. There were 7 replications per treatment. The data for all three tests were transformed [log (x+1)] and subjected to analysis of variance. Significant means were separated with Tukey's Test (P = 0.05).

Results and Discussion: Similar results were obtained from all three tests, which is noteworthy because of the tremendous size differences in the experimental unit (i.e. 8-oz versus 3-gal versus 45-gal containers). In all cases, the combination treatment of Talstar and *H. indica* provided the best control suggesting a synergy or additive effect between the insecticide and entomopathogenic nematode. In the first test (8-oz containers), the Talstar-nematode combination treatments provided the highest mortality of the larvae (Table 1). The number of live larvae in the combination treatments was generally lower than all other treatments. Only two treatments, the high rate of nematodes with either rate of Talstar, achieved 100% control, and these two treatments were significantly lower than the control at all evaluation times and significantly lower than either rate of nematodes used alone at 3, 4, 5, and 6 days after treatment. However, high rate *H. indica* plus Talstar were not significantly different from other treatments with Talstar during most evaluation periods, but again, were the only two treatments resulting in 100% control.

In the second test (3-gal containers), there were no significant differences in any of the treatments due to larval age (5, 7, and 9^{th}), so the data were combined for analysis. The combination treatment of Talstar and nematodes provided the best control, which was significantly different from all other treatments (Fig. 1). The combination treatment provided a 94% reduction compared to the control. Talstar alone provided a 73% reduction compared to the control. Flagship or nematodes alone provided poor control and were not significantly different from the control.

In the third test (45-gal containers), the rate of nematodes used was very high (9.8 billion/A), which was equivalent to a little more than one million nematodes per container. Reduced rates of the nematodes may also be effective, but more testing is necessary. The combination of Talstar and the nematodes provided 100% control, which was significantly different from all other treatments (Fig. 2). Talstar or nematodes alone each provided approximately 75% and 59% reduction of larvae compared to the control, respectively.

Although more testing is necessary to determine optimal rates of a combination treatment of Talstar and the nematodes, it is clear that the combination of these two products provided increased control compared to either product used alone. This may provide an opportunity to reduce the rate of insecticide required for control and may also provide an option of control for the larger, older larvae that have been traditionally difficult to kill.

Significance to Industry: Growers infested with *D. abbreviatus* are required to treat for this pest, particularly if shipping to Texas or California, which are extremely concerned about the introduction of *D. abbreviatus*. Although there are data for management of this pest in citrus, there is little to no data for soil treatments for immature stages of this pest in ornamentals. Therefore, there is not only a tremendous need for efficacious treatments in ornamentals, but also a need for data supporting these treatments. These data also promote the possibility of using a biological control agent as part of a regulatory treatment.
Acknowledgement: The author thanks FMC Corporation for providing insecticide, Integrated Biocontrol Systems for providing nematodes, and Suzanne Fraser (Florida Department of Agriculture and Consumer Services, Division of Plant Industry) for insect larvae.

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Table 1. Mean number live larvae (*Diaprepes abbreviatus*; 9th instar) exposed to bifenthrin (Talstar) and entomopathogenic nematodes (*Heterorhabditis indica*) in 8 ounce containers filled with potting media.

	Mean No. Live Larvae				
Treatment	2 DAT	3 DAT	4 DAT	5 DAT	6 DAT
H. indica – Low[1]	2.6 ab[3]	2.1 a	1.7 ab	1.5 b	1.2 bc
H. indica - high[1]	2.5 ab	2.2 a	1.7 ab	1.3 bc	1.3 ab
Talstar – low[2]	1.9 abc	1.4 ab	1.2 bc	1.0 bcd	0.9 bcd
Talstar – high[2]	2.0 abc	1.7 ab	1.4 ab	1.1 bc	0.9 bcd
H. indica-low + Talstar-low	1.5 bc	0.7 b	0.6 bcd	0.3 cd	0.2 cd
H. indica-low + Talstar-high	1.8 abc	1.7 ab	1.3 b	0.6 bcd	0.6 bcd
H. indica-high + Talstar-low	1.6 abc	0.7 b	0.0 d	0.0 d	0.0 d
H. indica-high + Talstar-high	1.1 bc	0.7 b	0.1 cd	0.0 d	0.0 d
Control	2.7 a	2.6 a	2.5 a	2.5 a	2.2 a

[1] *H. indica* – low = 1 billion per acre; *H. indica* – high = 2 billion per acre

[2] Talstar – low = 4.4 fl oz per 100 gal; Talstar – high = 8.9 fl oz per 100 gal (based on 25 ppm rate for bulk density of 739 lbs/yd^3)

[3] Means within columns followed by the same letter are not significantly different according to Tukey's Test ($P = 0.05$).

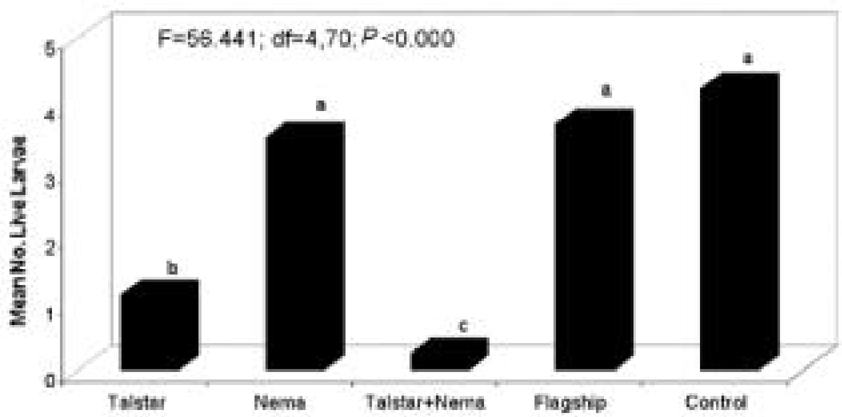

Fig. 1 Mean number of live larvae (*Diaprepes abbreviatus*; 5th, 7th, 9th instar) exposed to bifenthrin (Talstar) (8.9 fl oz per 100 gal), entomopathogenic nematodes (*Heterorhabditis indica*) (2 billion per acre), the combination of Talstar and *H. indica*, and thiamethoxam (Flagship) (17 oz per acre) in 3-gallon containers each planted with *Conocarpus erectus* (buttonwood).

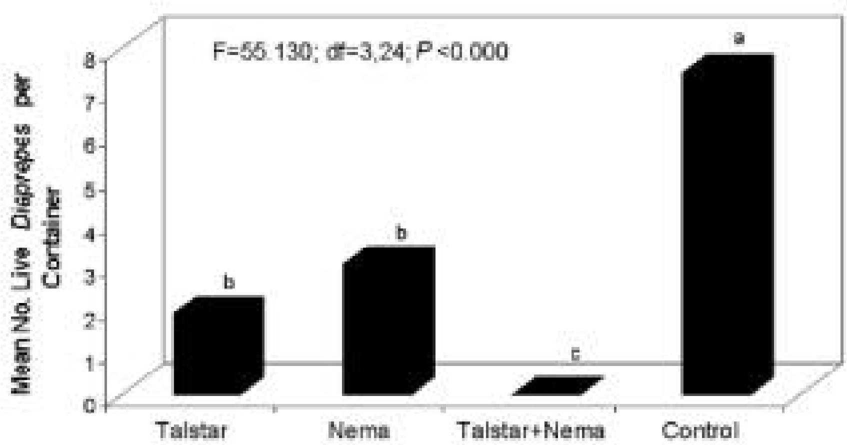

Fig. 2 Mean number live larvae (*Diaprepes abbreviatus*; 5th and 9th instar combined) exposed to bifenthrin (Talstar) (9.3 fl oz per 100 gal) and entomopathogenic nematodes (*Heterorhabditis indica*) (9.8 billion per acre or approximately 1 million per container) in 45-gallon containers each planted with *Bucida buceras* (big leaf black olive).

Insecticidal Dips and Other Strategies for Elimination of Japanese Beetle Larvae from Balled and Burlapped Nursery Stock

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Index Words: Japanese Beetle, *Popillia Japonica*, Insecticides, Entomopathogenic Nematodes, Quarantine, B&B Stock

Nature of Work: The Japanese beetle (*Popillia japonica* Newman) was first found in the U.S. around 1916, has expanded its range to the Mississippi River and beyond, and continues to be a pest of nursery, agricultural, and turf products. The annual cost of controlling larval and adult Japanese beetle has been estimated at > $460 million (1). In addition to direct costs, the beetle heavily impacts nursery trade through quarantines, and also impacts transportation industries (e.g., air cargo). The immature stages of the beetle can easily be transported with soil-bearing nursery stock. At the present time, movement of field nursery stock relies mainly on compliance with the U.S. Domestic Japanese Beetle Harmonization Plan (revised 2000) administrated by the National Plant Board (http://www.aphis.usda.gov/npb/jbplan.html). All nursery stock shipped from states determined to be infested (category 3 states) to states determined to be non-infested (category 1 states) or potentially infested (category 2 states) must meet required regulatory treatments. Dipping with Dursban is the only treatment that can be done in the fall immediately prior to shipment of nursery stock because no other treatments have been proven to work against the older, larger larvae. Many Tennessee producers shipping to category 2 states utilize a band application of Marathon 60WP (imidacloprid) during the early summer months. The objectives of this research were to: 1) find efficacious alternative products for Japanese beetle control, and 2) to find products with efficacy near the time of nursery stock shipping. To accomplish these objectives, a variety of products are being investigated, using multiple timings, rates, application methods, and interaction with biological agents. Japanese beetle field trials were established at multiple sites in Middle Tennessee during 2001. Soils in these tests were all loam or clay loam.

Surface Applied. Two commercial nurseries in Warren County, TN provided 100 redbud trees (*Cercis canadensis* L., ~ 1 to 3 in caliper) (Test 1), and 100 red maple (*Acer rubrum* L., ~ 2 to 5 in caliper) (Test 2). Ten treatments were each replicated 10 times (Table 1). Maximum rate treatments (3X) simulate the amount used in the tree row if the material was used in a banded, rather than a broadcast application. All treatments were applied with a CO_2 backpack sprayer (~ 28 psi) to a 9 ft^2 area (4 ft^2 in Test 2) to the mixed weed and grass ground cover. In Test 1, the area was maintained with periodic mowing. In Test 2, trees were artificially infested by caging adult Japanese beetles over the soil. All trees were harvested (24 in B&B) in mid-October and root balls examined for scarab larvae. Data were analyzed with analysis of variance (ANOVA) for a completely randomized design and means separated using Least Significance Difference Test (LSD) (SAS Institute 1997). Data were transformed with square root (X + 0.05).

Dip Screen. *Forsythia* and *Nandina* shrubs (12 to 15 in diam. B&B) were obtained from two commercial nurseries in Warren County, TN on 31 January 2001, and maintained on the soil surface. On 27 February 2001, each root ball was infested with five Japanese beetle grubs by making a small incision in the burlap at five separate points on the ball. Grubs that failed to enter the root ball on their own were replaced with new grubs. Treatments were applied to root balls on 3 March 2001 by hand-dipping the balls, and completely submerging them, for 1 minute in 114 L trash cans lined with disposable bags. Twelve treatments were each replicated 10 times (Table 2). Between 17 and 22 of May 2001, root balls were examined for grub survival. Data were analyzed as described in Surface Applied, above. In addition, Abbott's Formula (2) was used to adjust percent reduction estimates for pesticide- treated plants with respect to unexplained mortality in the non-treated control treatment.

Reduced Rate Chlorpyrifos Dip. White ash trees (*Fraxinus americana* L. var. Autumn purple) were planted at the TSU NCRS, McMinnville, TN during March 1998. Trees were grown to ~ 1 to 2 in caliper. During the summer of 2000, trees were artificially infested with adult Japanese beetles by caging beetles at the base of the trees. On 16 October 2000, trees were mechanically dug as 18 and 24 in root balls, wrapped with burlap, and placed in wire baskets. Trees were dipped individually for 2 minutes on 17 or 18 October 2000. Treatments included no chemical (water only control) or Dursban 2E (chlorpyrifos) at 0.125, 0.25, and 0.5 lb ai/100 gal water (i.e.,15.0, 30.0, and 60.0 g ai/L water) (replicated 10 times). Dipped root balls were returned to vacant root ball holes at the original site and covered with straw. Between 16 and 18 April 2001, root balls were removed from socket holes, wire baskets and burlap removed, and the entire root ball was broken apart to find surviving grubs. Grubs were identified to species, but only Japanese beetle larvae were numerous enough to analyze and report. Data were analyzed as described in Surface Applied, above.

Results and Discussion: Surface Applied. Japanese beetle grubs were completely eliminated by the higher rates of Flagship (Thiamethoxam) and Marathon and by both rates of Mach2 (halofenozide) in Test 1 (Table 1) (F = 2.45; df=9, 90; P = 0.015). Dylox (trichlorfon) treatments were applied at a time when grubs were in the second and third stadia. Therefore, Dylox impacted the most difficult to control stages. In Test 2 (F = 1.61; df=9, 90; P = 0.123), the control treatment again had the highest numerical count for Japanese beetle grubs, but differences between treatments were not significant (Table 1).

Dip Screen. Japanese beetle grubs were completely eliminated by all chemicals tested, except Precision 25WP (Table 2) (F = 18.06; df=11, 108; P = 0.0001). Nematode dips were significantly less effective than chemical agents. Nematode treatments averaged more than 1 grub per root ball (20% survival from original infestation of 5 grubs). The control treatment averaged 42% survival from initial infestations. Environment was probably not a factor in nematode efficacy, because water temperature (~ 60 to 70^{o}F) and pH (~ 7.5) were within the optimum range for nematode survival and activity. This test demonstrated that products other than chlorpyrifos have potential as dipping agents for grub control. None of the root balls had more Japanese beetle grubs than the original infestation number, so natural infestations were probably minimal.

Reduced Rate Chlorpyrifos Dip. Japanese beetle grubs were completely eliminated by all rates of chlorpyrifos with grub numbers in treated balls significantly differing from the control treatment (F = 4.99; df = 7, 72; P = 0.0001) (Table 3). The lowest chlorpyrifos rate tested (0.125 lb ai/100 gal = 15 g ai/100 L) is 16 times lower than the rate currently recommended (2 lb ai/100 gal = 240 g ai/100 L) by the U.S. Domestic Japanese Beetle Harmonization Plan for B&B dip treatments.

Significance to Industry: These results complement other studies (3, 4, 5) which show that dipping is the only method at the present time which can consistently provide 100% control of Japanese beetle larvae in nursery stock. Reduced rates of Dursban and other chemicals should be considered for inclusion in the Harmonization Plan.

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Table 1. The effect of insecticides applied in June, August, and September 2001 on larval Japanese beetle in 24-in (60-cm) root balls (B&B) at two middle Tennessee nurseries.

Test 1				Test 2			
Chemical	Rate (g ai/A)	Timing	*Popillia japonica* (X +/- S.E.)	Chemical	Rate (g ai/A)[a]	Timing	*Popillia japonica* (X +/- S.E.)

Means within a column followed by different letters were significantly different ($P < 0.05$) (Proc GLM for completely randomized design on Sqrt (X + 0.5) transformed data with means separated by Least Significant Difference Test). Means presented are untransformed and standard errors are transformed.

Table 2. The effect of insecticides or nematodes applied as a dip treatment on larval Japanese beetle in 12-in (30-cm) root balls (B&B) at the Nursery Crop Research Station, McMinnville, Tennessee

Treatment	Rate b ai/100 gal IJs/100 gal	No. grubs (X +/- S. E.)	% control
Dursban Pro	1	0.0 +/- 0.00 a	100.0
Dylox 80 T&O	8	0.0 +/- 0.00 a	100.0
Flagship 25WG	0.13	0.0 +/- 0.00 a	100.0
Mach2 Liquid Turf	1.5	0.0 +/- 0.00 a	100.0
Marathon 60WP	0.4	0.0 +/- 0.00 a	100.0
Sevin SL	8	0.0 +/- 0.00 a	100.0
Talstar Lawn & Tree F	0.23	0.0 +/- 0.00 a	100.0
H. marelatus	1.81 million	1.4 +/- 0.20 b	63.3
Control	0.0	2.1 +/- 0.20 bc	0.0
H. bacteriophora	1.81 million	2.1 +/- 0.20 bc	0.0
Precision 25WP	0.065	2.3 +/- 0.20 cd	0.0
H. indica	1.81 million	3.1 +/- 0.10 d	0.0

IJS - infective juveniles of *H. bacteriophora*, *H. indica*, and *H. marelatus* all in genus *Heterorhabditis*. *H. bacteriophora* = HP88. Test was infested on 27 February, treated on 13 March 2001, and evaluated on 17 and 18 May 2001. Means within a column followed by different letters were significantly different (P< 0.05) (Proc GLM for completely randomized design on Sqrt (X +0.5) transformed data with means separated by Least Significant Difference Test). Means presented are untransformed and standard errors are transformed.

Table 3. The effect of Dursban 2E applied as a dip treatment on larval Japanese beetle in 18- and 24-in (45- and 60-cm) root balls (B&B) field collected at the Nursery Crop Research Station, McMinnville, Tennessee

Treatment	Root Ball Size (cm)	Rate (lb ai/100 gal)	*Popillia Japonica* (X +/- SE)
Dursban 2E	45	0.125	0.0 +/- 0.00 a
Dursban 2E	45	0.25	0.0 +/- 0.00 a
Dursban 2E	45	0.5	0.0 +/- 0.00 a
Control	45	0.0	1.8 +/- 0.30 b
Dursban 2E	60	0.125	0.0 +/- 0.00 a
Dursban 2E	60	0.25	0.0 +/- 0.00 a
Dursban 2E	60	0.5	0.0 +/- 0.00 a
Control	60	0.0	1.3 +/- 0.20 b

Means within a column followed by different letters were significantly different ($P < 0.05$) (Proc GLM for completely randomized design on Sqrt (X + 0.5) transformed data with means separated by Least Significant Difference Test). Means presented are untransformed and standard errors are transformed.

Control of Mites and Scale Insects with Soybean Oil

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Index Words: Botanical Oil, Integrated Pest Management, Organic Pest Control, *Euonymus alatus*, *Glycine max*, *Parthenolexanium fletcheri*, *Quadraspidiotus perniciosus*, *Tetranychus urticae*, *Thuja orientalis*, *Leidosaphes yanongicola*

Nature of Work: There is worldwide interest in the use of bio-rational pesticides that may be safer to the public and to the environment (5). Several botanical oils, including soybean (*Glycine max* [L.] Merrill) oil, were exempted by the Environmental Protection Agency from normal pesticide registration because they were relatively nontoxic to humans and were non-persistent with no significant adverse effects in the environment (6).

Petroleum-derived horticultural oils have been used in agriculture for pest control for more than 100 years (4). They are considered to be among the best available pesticides for controlling scale insects and mites on dormant plants (2). Oils are reported to be the only widely used class of insecticides or miticides to which very few, if any, insects or mites have not developed resistance (1).

The overall objective of this project is to evaluate the efficacy of soybean oil for controlling insect and mite populations on nursery crops and to develop improved formulations that can be available to the nursery producer. The standard formulation (TNsoy1) used in most experiments was prepared by premixing the soybean oil with Latron B-1956 Spreader-Sticker (Rohm and Haas, Philadelphia, Pa.) at a 10:1 ratio of soybean oil to the adjuvant. The TNsoy1 formulation was agitated and allowed to set for 30-60 min prior to mixing with water in the spray tank. The spray solution must be continually agitated in the spray tank to prevent rapid separation of the emulsion.

In our prior experiments, soybean oil emulsions were evaluated as dormant oil sprays to control overwintering insects. Dormant apple trees near Morristown, Tenn. that were infested with San Jose scale (SJS) (*Quadraspidiotus perniciosus* Comstock) were sprayed to runoff with a handgun on 9 Feb. 1993 with 0, 1.25, 2.5 or 5.0% soybean oil plus 0.6% Latron AG 1956 or 2.5% damoil (Drexel Chemical Co., Memphis). Treatments were randomized in an incomplete block design with five replicates of oil treatments and four replicates of a water sprayed control. Ten stems were collected from each tree on 23 Mar. 1993, and insect mortality was determined by examining ten "black cap" SJS on each apple stem. Black cap refers to a overwintering developmental stage of SJS. Spraying 1.25, 2.5, or 5.0% soybean oil resulted in 73, 85, or 95% mortality of SJS compared to 25 % mortality on water sprayed control trees, respectively.

In another experiment, treatments of 0, 2, 3, or 4% TNsoy1 were sprayed on 9 Mar. 1997 with a backpack mist blower (Stihl Inc., Virginia Beach, Vir.). The treatments were sprayed on field grown 'Globosa' arborvitae (*Thuja orientalis* L.) in a McMinnville, Tenn. nursery infested with Fletcher scale (*Parthenolecanium fletcheri* Cockerall). The treatments were arranged in a randomized complete block design with six replications containing two plants per experimental unit. Twig samples were collected 13 Mar. 1997 and scale mortality assessed by evaluating 100 scale insects per experimental unit. The winter-time sprays of 2, 3 and 4% soybean oil controlled more than 98% of the Fletcher scales.

In a similar experiment, dormant burning bush (*Euonymus alatus* Thunb.) plants at Opryland hotel (Nashville, Tenn.) infested with winged euonymus scale (*Leidosaphes yanongicola* Comstock) were sprayed with a hand-held sprayer on 18 Mar. 1997 with 2, 3 or 4% Tnsoy1 or a water sprayed control. The scale insects on control plants had 25% mortality associated with natural or environmental causes. However, scale insects on plants sprayed with 2, 3, and 4% TNsoy1 had 44, 56 and 62% mortality, respectively. The relatively lower efficacy in this trial was probably due to spray coverage or lack of agitation in the spray tank compared to spraying with a handgun or mist blower in the previous experiments.

Summer-time sprays of horticultural oil can control mite populations and some insects. We evaluated summer sprays of soybean oil for efficacy against two spotted spider mites (TSSM) (*Tetranychus urticae* Koch) on burning bush (3). Single sprays of 1, 2, or 3% TNsoy1 or 1% SunSpray Ultra-Fine oil using a Stihl mist blower reduced TSSM populations by 97-99% compared to water sprayed controls. In another experiment, a single spray of 0.75%, 1.0%, or 1.5% TNsoy1 reduced TSSM populations by > 95%, compared to populations on control plants. A single spray of 0.25 or 0.5% Tnsoy1 reduced mite populations by more than 70% and 85%, respectively. A second spray of 0.25% to 1.0% Tnsoy1 oil resulted in $\geq$ 93% control of TSSM compared to the water sprayed control. Predaceous mites, probably *Phytoseiulus persimilis*, were not significantly disrupted by the first oil application.

Phytotoxicity, such as defoliation or leaf yellowing, from the TNSoy1 can occur on ornamentals if the air temperature is above 90F. Typically, there were no visual symptoms of phytotoxicity. Ornamentals were monitored for several days after treatment and did show a short term reduction (3 days) in photosynthesis.

We are current developing and evaluating new formulations of soybean oil as well as evaluating botanical formulations such as PF1025, Golden Natural, and Eco-oil from private companies.

Significance to the Industry: Soybean oil is an environmentally-safe, renewable resource that effectively controls scale insects and mites. It is very unlikely that insect/mite pests will develop resistance to oil based pesticides, because oils apparently control insects and mites primarily by suffocation and/or membrane disruption. The use of botanical oils as pesticides is desirable in integrated pest management strategies in nurseries and urban environments. They are essentially nontoxic to humans, effectively reduce the populations of some pests, and are non-phytotoxic to most ornamental plants.

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Non-Target Deposition of Methiocarb Applied to a Foliage Plant Staging Area

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Nature of Work: Deposition of pesticides on non-target surfaces results in material, labor, and financial wastes. Previous studies have shown that broadcast application of granular formulated pesticides can result in significant non-target losses due to pot spacing and plant growth form. Gilliam et al. (1992) reported non-target deposition of granular, broadcast applied herbicides to empty containers ranged from 23-30% when the containers were placed pot-to-pot, and increased to 79-80% when the containers were spaced on 30 cm centers. Mahnken and Sckroch 91992) reported higher herbicide concentrations (relative to per-pot applications) leaving simulated nursery sites that were treated by broadcast applications, and suggested that those higher concentrations were likely due to deposition of the berbicides on ground surfaces surrounding the pots. The objective of this study was to characterize non-target deposition of spray-applied pesticieds under typical commercial shadehouse nursery conditions using methiocarb as a surrogate. Methicarb is the active ingredient in the commercial formulation of Mesurol® 75-W. Mesurol® (Gowan, Yuma, AZ) is an organophosphate insecticide, miticide, and molluscicide, of environmental concern due to its' toxicity to fish, birds, and aquatic organisms.

Two areas within a foliage plant nursery (Kraft gardens, Fort Pierce, FL) were selected for evaluation. These areas were used for staging plants, Weeping Fig (*Ficus benjamina* 'Monique') andLady Palm (*Rhapis excelsa*). Species evaluated were of a similar height (Table 1), but varied in structural character. The Weeping Fig was trained to a single trunk, while the Lady Palm, a clustering-type palm, had multiple cane-like trunks/stems and palmate leaves with five to ten segments, divided almost to the base. Each aisle within these blocks was surrounded by two rows (double-row) of plants on each side. These rows were 21.9 m (72 ft) long. Thress aisles were chosen within each block of plants. Teflon targets measuring 5.08 x 5.08 cm (2 x 2 in) were placed at each end of the aisles, and a 5.5 m (18 ft) intervals between the two ends. Targets were also placed at the same distance intervals between one set of the two rows of plants on either side of the aisle.

Mesurol® 75-W was mixed at a rate of 0.45 kg (1 lb) per 379 L (100 gal) of spray mixturw. Mesurol® applications were made using a PTO-driven Berthoud Super Puma 1000 canon airblast sprayer calibrated to deliver 17.8 L (4.7 gal) of spray mixture per minute at a ground application speed of 0.1 m/sec. (0.23 mph). Following application, each target was placed in a polyethylene container, transported to the lab, and stored at -18C (-0.4F) until extracted and analyzed. Methocarb was extracted from the targets and dissolved in monochloroacetic acid buffer (pH 3) by vortexing and sonicating. Extracts were filtered, diluted 1:20, and analyzed using a Waters 2690 high pressure liquid chromatograph (HPLC) equipped with a post column reaction module, reagent managers, and a Waters 474 flourescence detector.

Results and Discussion: Mean deposition on the targets at each location (aisle vs. double-row) was calculated for each species (Figures 1 and 2). Ground deposition within aisles and double-rows was generally highest at the edges near the sprayer travel path. Deposition on targets placed within the aisles was generally similar to deposition on those placed between the plant rows at each respective location. Total ground depoisition within each aisle-rwo unit was estimated by averaging adjacent concentrations [i.e. (North edge+18 ft)/2, (18 ft+Center)2, etc.] and assuming that the calculated average concentration was representative of the deposition within that 18 linear foot section (four total sections = 72 ft) of the aisle-row unit. The average deposition for each 18 ft section was then summed to estimate total ground deposition within the aisle-row units. Ground deposition was expressed in terms of the percentage of the total amount applied to each unit. The total amount of methiocarb applied to each aisle+double-row unit based on the application rate was 5514 mg (0.19 oz) for Weeping Fig and 4666 mg (0.16 oz) for Lady Palm. Based on these estimates, 22% of the calculated mass of methiocarb applied over the aisle spaces, and 22% of the amount applied over the row spaces was deposited on ground surfaces (Figure 3). For Lady Palm, 17% of the pestcide applied over the aisle spaces and 12% of the calculated total applied over the double-row spaces was deposited on ground surfaces.

Significance to Industry: Results from this study show that significant amounts of spray-applied pesticides can be deposited on non-target ground surfaces. Depending on the pesticide, these residues may readily move off-site in surface runoff water where they my harm non-target fish, birds, and aquatic organisms. Pesticide applicators should be familiar with the toxicity of the pesticide to non-target organisms as indicated on the label or other sources. Applications of very toxic compounds should be made as far in advance of irrigation or inclement weather as possible. This allows more time for breakdown and aging of residual pesticides, which may reduce the toxic effects of the pesticide to non-target organisms. Pesticide application equipment should be calibrated and well maintained to prevent over application.

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Table 1. Study area and plant dimensions.

	***Ficus benjamina* 'Monique'**		***Rhapis excelsa***	
	M (Ft)	*STDEV.*	M (Ft)	*STDEV.*
Plant Height	1.09 (3.6)	*0.03 (0.1)*	0.7 (2.3)	*0.15 (0.5)*
Trunk Length	0.58 (1.9)	*0.03 (0.1)*	NM	*NM*
Pot Height	0.24 (0.8)	*NV*	0.34 (1.1)	*NV*
Canopy Width	0.58 (1.9)	*0.03 (0.1)*	0.64 (2.1)	*0.09 (0.3)*
Pot Spacing	0.64 (2.1)	*0.03 (0.1)*	0.69 (2.3)	*NV*
Aisle Width	0.99 (3.25)	*NV*	0.69 (2.3)	*NV*
Row/ Aisle Length	21.9 (72)	*NV*	21.9 (72)	*NV*

NM: *Not measured due to bushiness and multiple trunk character of plants, but is approximately equal to plant height.*

NV: *Considered constant with no variation.*

Figure 1. Methiocarb deposition on 5.08 x 5.08 cm (2 x 2 in.) targets within Weeping Fig aisles and double-rows. Bars represent one standard deviation from the mean (*N=3*).

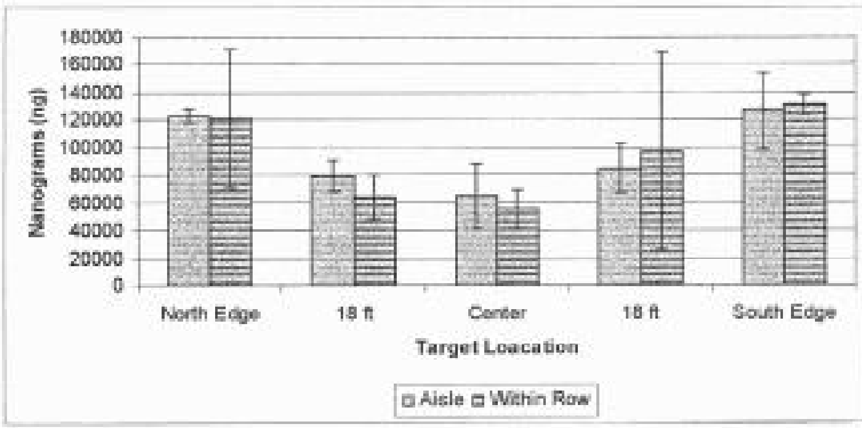

Figure 2. Methiocarb deposition on 5.08 x 5.08 cm (2 x 2 in.) targets within Lady Palm aisles and double-rows. Bars represent one standard deviation from the mean (*N=3*).

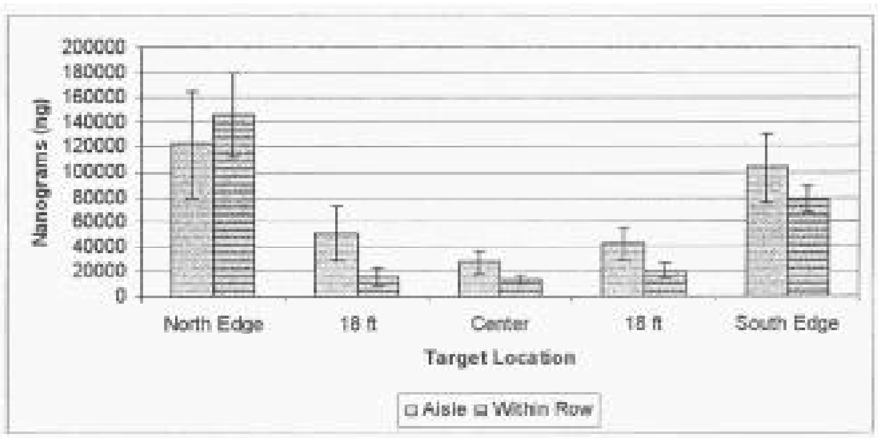

Figure 3. Estimate of percentage of total amount of methiocarb applied that was deposited on non-target ground surfaces.