Preventing White Grub Infestation in Container-Grown Nursery Stock[1]

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Abstract

Preplant media incorporation of Talstar 0.2 G (bifenthrin) at 10 ppm (parts per million) or Fireban 1.5 G (tefluthrin) at 15 ppm, based on dry weight of the medium, provided complete control of Japanese beetle (*Popillia japonica* Newman), oriental beetle [*Exomala orientalis* (Waterhouse)], and European chafer [*Rhizotrogus majalis* (Razoumowsky)] in container nursery plants for two growing seasons. Talstar 0.67 F drenched immediately after planting also prevented establishment of these species in containers for two growing seasons. Marathon 1 G (imidacloprid) preplant media incorporated at 6–17.8 g (a.i.)/m^3, provided incomplete control, while Marathon 60 W was completely effective when drenched in mid-summer prior to inoculating the pots with eggs. Other granular products mixed into potting media, including 10 ppm of fipronil or Mach 2, or 150 g (a.i.)/m^3 of Lorsban or SuSCon Green, provided good control for one season. Several treatments prevented establishment of Japanese but not oriental beetle grubs. Curative drenches were generally ineffective. Registered treatments providing two years of control (Talstar at 10–25 ppm) can be used by growers to prevent white grub larval establishment in containers. Their usage should allow shipment of treated plants throughout the United States and Canada.

Index words: scarabaeidae, European chafer, Japanese beetle, oriental beetle, control, quarantine.

Chemicals used in this study: acephate (Orthene 75 S) O,S-dimethyl phosphoramidothioate; bendiocarb (Turcam 76 W) 2,2-dimethyl-1,3-benzodioxol-4-yl methylcarbamate; bifenthrin (Talstar 0.2 G, Talstar F) 2-methyl (1,1'-biphenyl)-3-yl methyl 3-(2-chloro-3,3,3,-trifluoro-1-propenyl)-2,2-dimethylcyclopropanecarboxylate; carbofuran (Furadan 4 F) 2,3-dihydro-2,2-dimethyl-7-benzofuranyl methylcarbamate; chlorpyrifos (Lorsban 15 G, Dursban Turf, SuSCon Green) O,O-diethyl O-(3,5,6-trichloro-2-pyridinyl)phosphorothioate; disulfoton (Di-Syston 15 G) O,O-diethyl S-[2-(ethylthio)ethyl] phosphorodithioate; fipronil (Chipco Choice) 5-amino-1-(2,6-dichlorotrifluoro-p-tolyl)-4-trifluoromethylsulfinyl-pyrazole-3-carbonitrile; halofenozide (Mach 2 2SC) 4-chloro-2-benzoyl-(1,1-dimethyl) hydrazide benzoic acid, imidacloprid (Marathon 60 W, Marathon 1 G) 1-[(6-chloro-3-pyridinyl)methyl]-N-nitro-2-imidazolidinimine; isofenphos (Oftanol 2) 1-methylethyl 2-[[ethoxy[(1-methylethyl) amino]-phophinothioyl]oxy]benzoate; tefluthrin (Fireban 1.5 G) 2,3,5,6-tetrafluoro-4-methylbenzyl cis-3-(Z-2-chloro-3,3,3-trifluoroprop-1-enyl)-2,2-dimethylcyclopropanecarboxylate.

Significance to the Nursery Industry

White grubs, larvae of scarab beetles, damage and destroy roots of their hosts and can cause rejection of nursery stock for interstate and international commerce. Preplant incorporation of Fireban 1.5 G (tefluthrin) or Talstar 0.2 G (bifenthrin) can provide multi-year protection of container-grown nursery stock from these larvae. The labeled rate of Marathon 60 W (imidacloprid), drenched during mid-summer, also provided complete control of Japanese and oriental beetle larvae during the year of application. Product cost for preplant incorporation of Talstar is about 1 cent per #1 container (2.5 liter), depending upon the bulk density of the growing medium. The Talstar F drench treatment is about the same cost, and may be appropriate for established plants. Marathon 1 G preplant incorporation costs 17.5 cents per #1 container; the extra cost may be partially offset by the expected control of honeydew-producing insects and leaf miners. Fireban 1.5 G is labeled only for control of fire ants [*Solenopsis geminata* (Fabricius)] in nursery containers. Further studies are needed to determine the rate of insecticide loss from different kinds of container media under various growing conditions.

Introduction

The larvae of scarab beetles (Coleoptera: Scarabaeidae), commonly called white grubs, were often pests of nursery crops prior to 1948, when chlorinated insecticides (cyclodienes) were approved for disinfesting plants and preventing further infestation (5). Commonly used in potting mixes or incorporated into the soil of field-grown nurseries, cyclodiene insecticides provided up to four years of certifiable protection from Japanese beetle larvae (5). When registrations of cyclodienes were rescinded in the 1970s, white grubs became more prevalent in woody plant nurseries.

The species of pest scarabs varies with location. In the Northeast, exotic (non-native) species infest nurseries. Ranked in importance, in terms of abundance and damage potential, they are: oriental beetle [*Exomala orientalis* (Waterhouse)], Japanese beetle (*Popillia japonica* Newman), European chafer [*Rhizotrogus majalis* (Razoumowsky)], and Asiatic garden beetle [*Maladera castanea* (Arrow)]. Additional species of concern in the Midwest include northern masked chafer (*Cyclocephala borealis* Arrow), rose chafer [*Macrodactylus subspinosus* (Fabricius)], and May or June beetles (*Phyllophaga spp.*). On the West Coast, native species of white grubs, most notably the carrot beetle [*Ligyrus gibbosus* (De Geer)] and a masked chafer (*C. pasadenae*), occur in container-grown nursery stock.

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The importance of managing these pests in nurseries is two-fold. Larvae consume roots, causing wilting or death of plants. Injury to nursery stock may not become apparent until after sale or following transplant stress. Secondly, state phytosanitary statutes prohibit interstate and international shipment of infested nursery stock.

Though the Federal Japanese beetle quarantine was discontinued in 1978, seven western states and British Columbia maintain quarantines against Japanese beetle. From 1994 to 1996, a U.S.-Canada Harmonization Plan allowed container-grown plants to be shipped from the United States as long as plant inspectors determined a prescribed number of pots, representative of the shipment, were free of Japanese beetle larvae. In 1996, based on survey data indicating that Japanese beetles are unlikely to infest weed-free container-grown nursery stock (6), the Harmonization Plan eliminated the requirement for pot sampling with the exception of ornamental grasses and sedges. Oriental beetle, however, commonly infests containers, and other species mentioned above have historically been detected in containers. Plant inspectors at a receiving state may enforce plant pest-cleanliness statutes by rejecting nursery stock based on the presence of any white grub. Therefore, many states require compliance with a *de facto* quarantine against all white grub species, and growers consequently must continue to ship plants free of white grubs.

Growers need improved methods for either preventing infestation by scarabs or eliminating larvae from nursery stock. The method currently accepted by states with quarantines is pot dips with Dursban (chlorpyrifos) or Oftanol (isofenphos), a very labor- and chemical-intensive procedure. Curative treatments must be timed to follow the hatch of all eggs, and small larvae are difficult to detect. Furthermore, plants subjected to these treatments may suffer phytotoxicity (Nielsen, personal experience). From a plant production and plant health view, some root loss may occur before curative treatments can be applied.

The goal of the work reported here was to find products and treatment methods that provide alternatives to conventional pot dips, to either prevent infestation by white grubs or to disinfest pots. Options investigated were: preplant potting media incorporation, preventive drenches, and curative drenches. Materials chosen for this study emphasized newer insecticide chemistries with low mammalian toxicity (fipronil, Fireban, Mach 2, Merit and Talstar). The experiments in Ohio were designed to determine if products provide more than one year of control.

Materials and Methods

Products tested. The following products were evaluated in either Connecticut or Ohio: EXP61151A 0.1 G, EXP60818A 0.1 G and EXP60720A 80 WG (fipronil) by Rhône-Poulenc, Research Triangle Park, NC; Lorsban 15 G (chlorpyrifos) by DowAgriSciences, Indianapolis, IN; Mach 2 2 SC (halofenozide) by RhoMid L.L.C., Parsippany, NJ; Orthene 75 S (acephate) by Valent U.S.A., Walnut Creek, CA; SuSCon Green (chlorpyrifos 10% control release granules) by Crop Care Australasia, Brisbane, Australia; Turcam 76 W (bendiocarb) by AgrEvo, Wilmington, DE; Marathon 1 G and 60 WP (imidacloprid) and Oftanol 2 F (isofenphos) by Bayer, Indianapolis, IN; Fireban 1.5 G (tefluthrin) by Uniroyal, Middlebury, CT; Furadan 4 F (carbofuran), Talstar 0.2 G and 0.67 F (bifenthrin) by FMC Corp., Philadelphia, PA; Cruiser (*Heterorhabditis bacteriophora*) by Ecogen, Langhorne, PA. Labeled rates were used for registered products.

Ohio tests: Japanese beetle. The potting medium had a dry bulk density of 234 kg/m^3 (393 lb/yd^3), and consisted of pine bark, hardwood bark and peat (3:1:1 by vol), amended with pelletized lime, epsom salts, 0–46–0 fertilizer, Perk (micronutrient mix), and pelletized gypsum (3.2, 0.2, 0.3, 1.2, and 0.3 kg/m^3, respectively). Granular preplant incorporated treatments were hand-mixed with potting medium in a plastic tray.

Cotoneaster apiculatus 'Coral Beauty' were planted into #2 containers with treated and untreated media on May 9, 1996. Talstar F drenches were applied immediately after planting. Fipronil, Furadan, nematodes and Oftanol were drenched on September 17, 1996, after pre-wetting the potting medium. Treatments simulating broadcast applications, with rates expressed as kg/ha (Tables 1 and 2) were applied to individual pots with the dosages determined by the surface area of the media. Plants were maintained outdoors under standard nursery management conditions, including fertilization and overhead irrigation, in a shaded area at the OARDC, Wooster, Ohio. They were overwintered in a polyhouse. Phytotoxicity was assessed 7 and 14 days after treatment, throughout the growing seasons and when efficacy was measured, for both years of this study.

Eight replicate pots received selected treatments in 1996. Four replicates were each inoculated with 20 Japanese beetle eggs on July 29, 1996; the remaining 4 replicates were not inoculated until 1997. Individual eggs were placed in 1 cm (0.5 in) depressions, then immediately covered with medium. In the second year of this study, each pot received 25 eggs on both July 31 and August 1. Eggs were obtained from field-collected adults held with moist sand and fed birch foliage and apple slices. Pots were arranged in a randomized complete block design following treatment. Efficacy was evaluated by carefully removing media from roots held over a plastic tray, while two observers watched for larvae. Treatments were evaluated on October 31 in 1996, and on October 24–27 in 1997. Larval counts were subjected to square root transformation $\sqrt{(x + 0.5)}$ to establish homogeneity of variance before conducting analysis of variance (Proc GLM, SAS Institute, Cary, NC). Statistical significance for individual treatments was evaluated with Dunnett's test.

Ohio tests: oriental beetle and European chafer. Methods and materials were the same as for the Japanese beetle tests, except *Juniperus chinensis* were planted in #2 containers on May 2, 1996. Eight replicate pots received each granular treatment in 1996; each drench treatment was replicated with 4 pots. Four pots with each treatment were inoculated with 5 oriental beetle eggs and 9 European chafer eggs on July 5 and 15, 1996, respectively. The two groups of eggs were placed on opposite sides of the plant. In 1997, the other 4 pots with granular treatments were inoculated with 3 oriental beetle eggs and 15 European chafer eggs each on July 22 and 23, respectively. European chafer eggs were obtained from field-collected adults placed with moist sand. Oriental beetle adults were obtained from larvae collected as late instars in Rhode Island. They, too, were caged with moist sand to obtain eggs. Treatments were evaluated on October 30, 1996, and October 16, 1997.

Table 1. Effect of insecticide treatments for controlling Japanese beetle, oriental beetle, and European chafer larvae in #2 containers during the first year of treatment (Ohio tests, 1996 results). Treatment rates expressed as parts per million (ppm) are based on the weight of active ingredient (a.i.) per dry weight of medium.

Treatment[z]	Rate (a.i.)	Live larvae (mean ± SE)[y] Japanese beetle	Oriental beetle and European chafer
Preplant			
EXP60818A 0.1 G	1.25 ppm	0.0 ± 0.0**	—
EXP60818A 0.1 G	2.5 ppm	0.3 ± 0.3**	—
EXP60818A 0.1 G	5 ppm	0.0 ± 0.0**	—
Fireban 1.5 G	15 ppm	0.0 ± 0.0**	0.0 ± 0.0**
Fireban 1.5 G	25 ppm	0.0 ± 0.0**	0.0 ± 0.0**
Lorsban 15 G	150 g/cu m	0.0 ± 0.0**	1.5 ± 1.5*
Marathon 1 G	7.6 g/cu m	0.0 ± 0.0**	0.0 ± 0.0**
Talstar 0.2 G	10 ppm	0.0 ± 0.0**	0.0 ± 0.0**
Talstar 0.2 G	25 ppm	0.0 ± 0.0**	0.0 ± 0.0**
Talstar 0.2 G	50 ppm	0.0 ± 0.0**	—
Postplant			
Cruiser (nematode)[x]	20,000	4.0 ± 0.9	5.0 ± 1.8
Cruiser (nematode)	30,000	3.5 ± 1.7	6.0 ± 1.3
EXP60818A 0.1 G	2.2 kg/ha	0.0 ± 0.0**	—
EXP60720A 80 WG	2.2 kg/ha	2.0 ± 0.4	—
EXP60720A 80 WG	4.5 kg/ha	0.3 ± 0.3**	—
Furadan 4 F[w]	140 mg	0.3 ± 0.3**	0.0 ± 0.0**
Oftanol 2	2.2 kg/ha	0.0 ± 0.0**	3.0 ± 0.8
Oftanol 2	4.5 kg/ha	0.0 ± 0.0**	1.0 ± 0.4*
Talstar 0.67 F	0.22 kg/ha	0.0 ± 0.0**	—
Talstar 0.67 F	0.45 kg/ha	0.0 ± 0.0**	—
Untreated check	—	1.5 ± 1.0	5.0 ± 1.8

[z]We used 470 ml of finished material per pot for Talstar F and Oftanol.

[y]Means within the Japanese beetle column significantly different from the 'Cruiser' treatments: **, $P < 0.001$. Treatment means compared to 'Cruiser,' because Japanese beetle larvae did not colonize 2 of the 4 check containers. Means within the oriental beetle column significantly different from check treatment: *, $P < 0.05$; **, $P < 0.001$; Dunnett's test.

[x]Number of infective juvenile nematodes per pot, applied in 120 ml water.

[w]Applied in 950 ml water per pot.

Table 2. Effect of insecticide treatments for controlling Japanese beetle, oriental beetle, and European chafer larvae in #2 containers during the second year following treatment (Ohio tests, 1997 results). Treatment rates expressed as parts per million (ppm) are based on the weight of active ingredient (a.i.) per dry weight of medium.

Treatment[z]	Rate (a.i.)	Live larvae (mean ± SE)[y] Japanese beetle	Oriental beetle and European chafer
Preplant			
EXP60818A 0.1 G	1.25 ppm	5.3 ± 0.75	—
EXP60818A 0.1 G	2.5 ppm	3.8 ± 1.55	—
EXP60818A 0.1 G	5 ppm	0.8 ± 0.75*	—
Fireban 1.5 G	15 ppm	0.0 ± 0.0**	0.0 ± 0.0**
Fireban 1.5 G	25 ppm	0.0 ± 0.0**	0.0 ± 0.0**
Lorsban 15 G	150 g/cu m	6.3 ± 1.7	1.0 ± 0.7**
Marathon 1 G	7.6 g/cu m	0.0 ± 0.0**	0.0 ± 0.0**
Talstar 0.2 G	10 ppm	0.0 ± 0.0**	0.0 ± 0.0**
Talstar 0.2 G	25 ppm	0.0 ± 0.0**	0.0 ± 0.0**
Talstar 0.2 G	50 ppm	0.0 ± 0.0**	—
Postplant			
EXP60818A 0.1 G	2.2 kg/ha	0.0 ± 0.0**	—
EXP60720A 80 WG	2.2 kg/ha	8.8 ± 1.7	—
EXP60720A 80 WG	4.5 kg/ha	8.5 ± 1.0	—
Talstar 0.67 F	0.22 kg/ha	0.0 ± 0.0**	—
Talstar 0.67 F	0.45 kg/ha	0.0 ± 0.0**	—
Untreated check	—	3.0 ± 0.41	4.0 ± 0.9

[z]We used 470 ml of finished material per pot for Talstar F.

[y]Means within columns significantly different from the check: *, $P < 0.05$; **, $P < 0.001$; Dunnett's test.

Connecticut test: Japanese and oriental beetles. Pots (#1, 2.5 liter) were loaded with each of two potting mixes. The shrub mix had a dry bulk density of 610 kg/m^3 (1020 lb/yd^3) and consisted of 7:2:1 (by vol) hardwood compost, peat and sand. The rhododendron mix had a much coarser texture, a dry bulk density of 480 kg/m^3 (804 lb/yd^3), and consisted of peat, pine bark, composted hardwood bark, styrofoam and gravel in a 3:3:2:1:1 ratio. Media were amended with lime (2 and 0.6 kg/m^3, respectively) and 2.6 kg/m^3 of controlled release complete fertilizer. Pots were arranged in a randomized complete block design of 23 treatments and 5 replicates. To avoid overheating of pots due to solar energy, which could be lethal to white grub larvae (5), pots were sunk into the ground so that the surface of the medium was level with the soil outside the container. Each pot was then seeded on May 13, 1997, with approximately 5 greater quaking grass (*Briza maxima*) seeds. This plant was chosen because it is one of the ornamental grasses shown to support Japanese beetle larvae in nurseries (6). The nursery site provided overhead irrigation using impact sprinklers.

Japanese beetle adults were collected in Kingston, RI, using a floral/sex attractant lure. Oriental beetle larvae were collected from turf in Norwich, CT, using a sod cutter, and allowed to complete development to the adult stage while individually caged with soil and grass seed mix (3). Sand sifted through a 20-mesh screen was moistened and placed 15 cm deep (6 in) in a 20-liter plastic bucket. Adults (Japanese beetles or oriental beetles) were placed in the bucket with grape foliage and enclosed with perforated polyethylene. Adults were placed in clean cages with fresh food on a weekly basis. Eggs deposited in the sand were collected using a 20-mesh screen and kept in a cooler until used for inoculating pots.

To infest pots, several 2-cm deep pits were made adjacent to the base of quaking grass plants; eggs placed in the bottom of the pits were then covered with potting medium. Peak egg laying occurred at the end of July. Approximately 20 oriental beetle eggs were placed in each pot on July 30, with another 5 eggs per pot on July 31. Approximately 40 Japanese beetle eggs were placed in each pot on July 31.

A small concrete mixer incorporated preplant treatments with media. Mach 2 was first suspended in water (equivalent to 40 ml per pot) and sprayed into the media while mixing. The mixer was washed between batches requiring different active ingredients. Chemical drenches were applied as a 200 ml volume per pot: preventive treatments were applied on July 18; curative treatments on October 9, 1997. Granular products applied in July or October were spread on the surface of the pot, requiring irrigation and rain to carry the active ingredient into the potting medium.

Larval infestation was evaluated October 20–28, 1997, by removing the pot and manually sifting the media to find larvae. Larvae were identified as Japanese or oriental beetles by their characteristic rasters (7). Data were analyzed by the same methods as for the Ohio tests.

Results and Discussion

Ohio tests. Overall, larval establishment in untreated, check pots was good. Only in 1996 did Japanese beetle larvae fail to establish in 2 of the 4 check pots. However, since larvae became established in pots receiving ineffective treatments (see Cruiser data, Table 1), efficacy could still be evaluated. Several products provided complete control of Japanese beetles, oriental beetles, and European chafer for two growing seasons (Tables 1 and 2). Fireban, Marathon and Talstar granular products incorporated into media prior to potting prevented white grub eggs from hatching or killed early instars before any root damage occurred, both during the year of treatment and during the next growing season. The highest rate of EXP60818A (fipronil) was equally effective against Japanese beetle larvae. It and Fireban are not registered for this usage. Lorsban was effective against Japanese beetle larvae in the year of application and was significantly better than the untreated check against oriental beetle and European chafer larvae. However, it did not provide two years of protection. Furadan was effective as a curative treatment in late summer. Oftanol, another curative drench treatment, was more effective against Japanese beetle larvae than the other species. The nematode drench treatments (Cruiser, containing infective juveniles of *Heterorhabditis bacteriophora*) were ineffective against established white grub larvae. No phytotoxicity was observed.

Connecticut test. There was an average of 3.6 larvae per pot for combined counts of both grub species in untreated pots (Table 3). Both oriental and Japanese beetle larvae became established: at least one larva was present in every untreated pot. Larval establishment was affected by potting medium: there were 0.86 larvae in the shrub mix and only 0.50 larvae in the rhododendron mix, averaged over all treatments ($F_{[1,180]} = 8.30$, $P < 0.01$, for potting mix main effect). Since soil × treatment interactions were not significant ($F_{[22,180]} = 1.48$, $P = 0.08$), treatment main effects (averaged over soil types) are reported here.

A wide variety of treatments provided statistically significant control ($F_{[22,180]} = 6.79$, $P < 0.001$). Outstanding control, giving 100% mortality of both Japanese beetle and oriental beetle larvae, was achieved with 4 treatments: preplant potting mix incorporation of Talstar 0.2 G at 5, 10 and 20 ppm, and the mid-season drench at the high labeled rate for Marathon 60 W. Unlike the tests in Ohio, preplant incorporation of Marathon 1 G did not provide complete control of white grubs. Earlier treatment timing (preplant mix vs. mid-season vs. curative application) generally improved control of larvae, possibly by allowing better distribution of active ingredient in the root zone and by allowing interaction of early stage larvae with insecticide. In general, curative treatments were not effective. We attribute the poor performance of the curative treatments to inadequate distribution of active ingredient through the container media. At the time of application, the nursery had minimized irrigation in the area where the experiment was located. Larvae had started moving downward in the pots, so materials that bind tightly to organic matter near the top of the pot, like chlorpyrifos (3), would not have been expected to come in contact with larvae.

Oriental beetle larvae appeared to be somewhat more difficult to kill than Japanese beetle larvae. There were fewer effective treatments for oriental beetle than for Japanese beetle. For example, both rates of Mach 2 gave 100% control of Japanese beetle larvae, but oriental beetles were only suppressed by the high rate. A greater sensitivity of Japanese beetle is expected with this active ingredient, based on laboratory dose-response studies (4). Similarly, both rates of SuSCon Green provided 100% control of Japanese beetle for one year, but the high rate only suppressed oriental beetle larvae.

Practical considerations. Appropriate control methods are available for various situations. Some growers hesitate to treat media before potting because of a perceived risk of worker exposure. Drench application can allay this concern and provide an option for protecting plants growing in previously untreated media. While still labor intensive, a drench treatment requires less labor than dip procedures. Of all options, preplant incorporation into media of granular formulations is the most labor-efficient practice.

The material costs vary widely for effective treatments (Marathon or Talstar) labeled for container-grown nursery stock. The costs for granular preplant potting mix treatments were calculated on a per-pot basis using a potting medium with a dry bulk density of 235 kg/m^3 (400 lb/yd^3) and a #1 container that holds ~2.5 liters of media. The cost per pot for Marathon 1 G ($720 for 40 lb product) is ca. 17.5¢; for Talstar 0.2 G ($60 for 50 lb) is ca. 1¢, based on the 10 ppm rate. Since #2 cans have about twice the volume as #1 cans, the cost would be 2¢ per #2 container for Talstar 0.2 G and 35¢ for Marathon 1 G. Talstar F, priced at $101 per quart, translates to a cost of 1.2¢ per #1 container at 10 ppm or 2.4¢ for the 20 ppm concentration in a #1 can. The comparative cost for Marathon 60 WP in the high-rate preventive drench is 32¢ per pot, assuming that one 20 g packet ($57.60) treats 180 #1 cans. Since treatment rates for Talstar are based on parts per million of active ingredient relative to the dry weight of the potting medium, the cost per unit volume is proportional to media bulk density. The cost for treating a specific potting mix can be calculated by using the above data and proportions for the dry bulk density of the medium to be used. For example, a potting mix with a bulk density of 315 kg/m^3 (534 lb/yd^3) would cost (315/235) × 1¢, or 1.3¢ per #1 can at the 10 ppm rate, using Talstar 0.2 G.

There are other factors besides cost to consider when comparing Marathon and Talstar. The Talstar preplant incorporation treatment also appears to be highly effective against black vine weevil larvae (2; Nielsen, unpublished data), while Marathon is only moderately effective. Marathon does provide excellent, long-residual systemic control of honeydew-producing insects and leaf miners. Eliminating foliar sprays to control these pests may help defray the expense for this material. Furthermore, if both white grubs and root weevil larvae can be controlled with a preplant potting mix, then

Table 3. **Effect of insecticide treatments for controlling Japanese beetle and oriental beetle larvae. Data are averaged over 10 pots (5 each from 2 potting media), sampled for larvae October 20–28, 1997. Treatment rates expressed in parts per million (ppm) are based on weight of active ingredient (a.i.) per dry weight of media.**

Treatment type (Application date) Trade name	Chemical name	Treatment rate (a.i.)	Larvae (mean ± SE)[z] Japanese beetle	Oriental beetle	Total
Preplant (7 May)					
EXP61151A 0.1G	fipronil	10 ppm	0.0 ± 0.0**	0.2 ± 0.2*	0.2 ± 0.2**
Mach2 2SC	halofenozide	10 ppm	0.0 ± 0.0**	0.3 ± 0.2*	0.3 ± 0.2**
Mach2 2SC	halofenozide	20 ppm	0.0 ± 0.0**	0.1 ± 0.1*	0.1 ± 0.1**
Marathon 1G	imidacloprid	6.0 g/m^3	0.5 ± 0.2**	1.0 ± 0.5	1.5 ± 0.7*
Marathon 1G	imidacloprid	17.8 g/m^3	0.0 ± 0.0**	0.1 ± 0.1*	0.1 ± 0.1**
SuSCon Green	chlorpyrifos	100 g/m^3	0.0 ± 0.0**	0.6 ± 0.2	0.6 ± 0.2**
SuSCon Green	chlorpyrifos	150 g/m^3	0.0 ± 0.0**	0.1 ± 0.1*	0.1 ± 0.1**
Talstar 0.2G	bifenthrin	5 ppm	0.0 ± 0.0**	0.0 ± 0.0*	0.0 ± 0.0**
Talstar 0.2G	bifenthrin	10 ppm	0.0 ± 0.0**	0.0 ± 0.0*	0.0 ± 0.0**
Talstar 0.2G	bifenthrin	20 ppm	0.0 ± 0.0**	0.0 ± 0.0*	0.0 ± 0.0**
Preventive treatment (18 July)					
EXP61151A 0.1G	fipronil	7.3 mg/pot	0.0 ± 0.0**	0.8 ± 0.4	0.8 ± 0.4**
EXP61151A 0.1G	fipronil	13.3 mg/pot	0.2 ± 0.2**	0.0 ± 0.0*	0.2 ± 0.2**
EXP60720A 80W	fipronil	7.3 mg/pot	0.4 ± 0.2**	1.0 ± 0.4	1.4 ± 0.5*
EXP60720A 80W	fipronil	13.3 mg/pot	0.4 ± 0.2**	1.9 ± 0.7	2.3 ± 0.9
Marathon 60W	imidacloprid	0.83 mg/pot	0.0 ± 0.0**	0.4 ± 0.3	0.4 ± 0.3**
Marathon 60W	imidacloprid	50 mg/pot	0.0 ± 0.0**	0.0 ± 0.0*	0.0 ± 0.0**
Talstar F	bifenthrin	10 ppm	0.0 ± 0.0**	1.0 ± 0.5	1.0 ± 0.5**
Curative treatment (9 October)					
DiSyston 15G	disulfoton	202 mg/pot	1.3 ± 0.5	1.5 ± 0.5	2.8 ± 0.8
Dursban 4E	chlorpyrifos	479 mg/pot	1.2 ± 0.4	0.7 ± 0.3	1.9 ± 0.5
Orthene 75S	acephate	90 mg/pot	1.0 ± 0.4	0.6 ± 0.3	1.6 ± 0.6*
Talstar F	bifenthrin	10 ppm	1.8 ± 0.7	1.2 ± 0.4	3.0 ± 1.0
Turcam 76W	bendiocarb	45.6 mg/pot	0.7 ± 0.3*	1.2 ± 0.6	1.9 ± 0.6
Untreated check		—	2.1 ± 0.7	1.5 ± 0.4	3.6 ± 0.6

[z]Means within columns significantly different from the untreated check;*, $P < 0.05$; **, $P < 0.001$, respectively; Dunnett's test performed on square-root transformed data.

foliar sprays directed against their adults may no longer be needed. Since some of the products used as adulticides are broad-spectrum insecticides and often are toxic to predatory insects and mites, eliminating those sprays may allow naturally occurring beneficial arthropods to exploit pest populations (1), further reducing the need for foliar sprays.

Good nursery and pest management practices suggest that growers should not consider highly effective chemical treatments to be stand-alone tactics for white grub control in container nursery production. Other practices can minimize the risk of egg-laying by adult scarabs and should be adopted as part of an integrated management program. For example, Japanese beetles may only lay eggs in container nursery stock in which grasses, sedges or weeds are growing, or that are immediately adjacent to grasses (6). Maintaining container areas free of weeds, especially grasses, is consequently important for reducing the risk of infestation by white grubs. Turf adjacent to growing sites should be treated with insecticides to control white grub larvae, thereby minimizing the flight of adults into container production areas.

The effectiveness of any treatment procedure should always be monitored in a nursery. A simple non-destructive method to check for the presence of white grubs in containers uses the knowledge that larvae migrate to the bottom of the pot in autumn. Slide the plant out of the container to check the bottom of the medium and inside the pot for overwintering larvae. If larvae are present, a curative treatment will be required prior to shipment.

Two aspects needing further quantification are the rate of loss for active ingredients in potting media, and the biological effect of that loss. The biological effect is the dose-response, or relationship of residue concentration vs. survival, for each species of white grub. Chemical analyses of residues remaining in container media aged for various lengths of time under various nursery conditions should allow us to predict (along with the dose-response) how long initial dosages of insecticide can be expected to provide protection against root-feeding larvae. If an active ingredient degrades or is lost from pots slowly enough, protection of plant material throughout normal crop cycles may be possible for at least some container-grown nursery stock. The two years of residual white grub control demonstrated in the Ohio experiments suggest that the active ingredients are degraded slowly or do not readily leach from the potting medium. Media from these two-year studies will be inoculated with scarab eggs in 1998 to determine if control persists through the third growing season.

Preplant incorporation of Fireban or Talstar, or a mid-summer drench with Marathon, provides complete control of Japanese beetle and oriental beetle larvae in nursery containers. These treatments are easier to apply than the curative Dursban or Oftanol dips, and should be pursued for certifying nursery stock for interstate or international shipment.

Literature Cited

1. Cowles, R.S. and T.M. Abbey. 1997. Integration of biological and chemical controls is used to manage the twospotted spider mite in container-grown nurseries. Yankee Nursery Quarterly 7(1):18–19.

2. Cowles, R.S., S.R. Alm, and D.O. Gilrein. 1997. The Trojan Horse of the nursery industry. Amer. Nurseryman 186(3):51–57.

3. Cowles, R.S. and M.G. Villani. 1994. Soil interactions with chemical insecticides and nematodes used for control of Japanese beetle (Coleoptera: Scarabaeidae) larvae. J. Econ. Entomol. 87:1014–1021.

4. Cowles, R.S. and M.G. Villani. 1996. Susceptibility of Japanese beetle, oriental beetle, and European chafer (Coleoptera: Scarabaeidae) to halofenozide, an insect growth regulator. J. Econ. Entomol. 89:1556–1565.

5. Fleming, W.E. 1972. Preventing Japanese beetle dispersion by farm products and nursery stock. USDA Tech. Bull. 1441. 256 pp.

6. Smitley, D.R. 1994. Dealing with the Japanese beetle: a new approach. Nursery Business Grower, August 1994, pp. 6–7.

7. Tashiro, H. 1987. Turfgrass Insects of the United States and Canada. Cornell University Press. Ithaca, NY.

Characteristics of Garden Writers and Their Information Sources[1]

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Abstract

A national survey of members of the *Garden Writers Association of America* (GWAA) indicated that Garden Writers tend to distribute their gardening communications within their state of residence and to a lesser extent, nationally. The most widely used media by Garden Writers were newspapers, magazines and television. The three types of plant material information that generated greatest consumer response for Garden Writers were low maintenance plants, herbaceous perennials, and new plant varieties. The type of services or information that Garden Writers valued the most were new plant releases, current pest problems in their area, and a listing of local suppliers of new plant varieties. Garden Writers maintain home gardens (97.3%) and most evaluate new plant varieties (88.1%) in their garden.

Index words: consumer education, marketing, ornamentals, new plants.

Significance to the Nursery Industry

This study characterizes Garden Writers that are members of the national association, *Garden Writers Association of America* (GWAA). Garden Writers serve the gardening public and are important conveyors of plant material information. Their information influences the purchasing decisions of consumers, especially at retail garden outlets. Plant producers can use the information in this study to develop and expand their retail marketing plans. Garden Writers would like to receive additional information from growers and other suppliers of gardening products. Garden Writers are particularly interested in new products and how to handle pest problems in their area. Providing samples of new products for use by Garden Writers in their home gardens is an important educational opportunity. The information in this study can be used to construct product catalogs and marketing communications programs for Garden Writers and consumers.

Introduction

Greenhouse and nursery crops are distributed primarily through two distribution channels, landscape and retail, to the consumer (2). Most growers market primarily to the customer involved with the purchase of the plant material. This may be the landscape contractor in the landscape market, or the retail garden outlet in the retail market. In many markets, the purchaser of a product may not be the person making the decision on the type of product to purchase or at a minimum, purchasing decisions are influenced by other groups (1). For instance in the landscape industry the landscape architect, who generally does not purchase plant material, greatly influences which plants are purchased by landscape installers (2, 5). In the retail market, Garden Writers are one such group

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