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Fall Subsurface Insecticide Treatments Control European Chafer Grubs Damaging Field-Grown Nursery Crops¹

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Abstract

Third instar European chafer (EC), *Rhizotrogus majalis* (Razoumowsky), were found to be killing field-grown Rhododendrons 'P.J.M.' and Eastern hemlocks in two commercial nurseries in northeastern Ohio. Apparently, 1 or 2 grubs per plant were sufficient to severely damage young plants (rhododendrons). Subsurface applications of Dursban TNP were tested as rescue treatments against the grubs in these fields. Three novel single-point subsurface applicators were tested for delivery of Dursban in the rhododendron trial. A subsurface treatment of Dursban TNP was compared to surface applied drench treatments of Dursban TNP and Dylox 80 T & O in the hemlock trial. We found that EC grubs killed young plants of both species by removing most of the fibrous roots and/or girdling the stems. The subsurface treatments of Dursban TNP, significantly reduced (95%) the number of EC grubs compared to untreated hemlocks and rhododendrons when treatments were applied early or late fall, respectively. There were no differences in suppression of grubs among the applicators in the rhododendron trial.

Index words: Canadian/Eastern Hemlock, *Tsuga canadensis* (L.), Rhododendron 'P.J.M.', *Rhododendron carolinianum* Rehder x *R. dauricum* L. var. *sempervirens*, Dursban TNP, Dylox 80 T & O, soil injection.

Chemicals used in this study: Dursban TNP, (chlorpyrifos), O-diethyl O-(3,5,6-trichloro-2-pyridinyl) phosphorothionate; Dylox 80 T & O, (trichlorfon), Dimethyl (2,2,2-trichloro-1-hydroxyethyl) phosphonate.

Significance to the Nursery Industry

This study provides further evidence that European chafer (EC) specifically, and exotic white grubs in general, can be serious pests of woody nursery crops in commercial nurseries (4, 6), and that, depending on plant size, relatively low numbers of grubs per plant can cause severe damage (6). Previously, EC was considered similar to the Japanese beetle as a problem in ornamental nurseries because it might be transported in the soil of balled and burlapped (B & B) stock and media of containerized plants, resulting in new infestations. We also report that subsurface treatments of insecticide, where insecticides are delivered directly to the root zone, can be very effective as rescue treatments against some species of white grubs (e.g. EC) infesting field-grown woody nursery crops. This technique has not generally been successful for applying insecticides against white grubs in field-grown stock.

Introduction

The European chafer (EC), *Rhizotrogus majalis* (Razoumowsky) (Coleoptera: Scarabaeidae), is an exotic pest

of turf and nursery crops. It is native to western and central Europe. In North America, it occurs in Connecticut, Massachusetts, Michigan, New Jersey, New York, Ohio, and Pennsylvania, USA and in Ontario, and British Columbia, Canada (1, 9). In locations where EC is established, the grubs (larvae) are often the most serious scarab pest of turf. Tashiro et al. (8) concluded that EC grubs were not a serious threat to damage woody nursery crops, only occasionally damaging lining-out stock. The primary concern in nurseries was transporting grubs in the soil of balled and burlapped (B & B) plants or media of container-grown plants to non-infested areas (8). However, recent reports (6) suggest that EC grubs are a more serious direct threat to nursery stock than previously believed. Smitley and Davis (6) reported that 20% of the plants in a field of Colorado blue spruce (*Picea pungens* Engelman) in a Michigan nursery were killed by EC grubs feeding on the roots.

In October 2001, last (third) instar EC grubs were killing young (planted late May 2001) Rhododendrons 'P.J.M.' (hybrid of *Rhododendron carolinianum* Rehder x *R. dauricum* L. var. *sempervirens*) in a nursery in northeastern Ohio. In September 2002, EC grubs were found to be killing young (planted late May 2002) Canadian/Eastern hemlock (*Tsuga canadensis* L.) trees in a different nursery in northeastern Ohio. We identified the grubs by their raster patterns and the shape of the anal slit (9). In both cases, the grubs were causing severe damage and plant death by feeding on the roots and girdling stems. Because EC grubs remain active at relatively low temperatures (4–10C (40–50F)), they continue feeding much later into the fall than most other scarabs (9). Consequently, additional damage to plants was expected in both cases, thus remedial action was considered necessary.

In turf, surface applied insecticides are relatively effective as rescue treatments against scarab grubs because the grubs usually feed near (≤ 5 cm (2 in)) the surface where most of the roots occur. These treatments have not been as effective against grubs in woody nursery crops. The root zones of field-grown woody nursery crops are generally deeper than

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turf. When scarab grubs infest nursery crops, they are often distributed throughout the root zone resulting in a larger proportion of the population deeper in the soil than when infesting turf (M.E.R. and M.G.K. personal observation). The farther the grubs are from the surface, the more difficult they are to reach with surface applied insecticides.

The growers in both nurseries were primarily interested in preventing further damage to their plants. A technique we expected to have a high probability of success involved subsurface application of insecticides where the toxicant is delivered directly to the root zone. Because the technique was experimental, both growers allowed us to use some of their plants to conduct trials. The objective of these trials was to test subsurface application of Dursban TNP as a rescue treatment against EC infesting field-grown woody nursery crops. Generally, although toxic to the grubs, Dursban would not be used because when applied as a surface treatment (drench or granular), the most common technique, Dursban adsorbs to organic matter (10) and surface treatments do not move into the root zone. Reduced-risk insecticides such as imidacloprid (Marathon) or halofenozide (Mach-2) are not effective at a rescue treatment timing (2, 3). To be effective they must be applied preventively, targeting the egg and first instar larval stages (2, 3). Because we were applying insecticide directly to the root zone and treating late-stage grubs, Dursban was a viable choice.

Materials and Methods

Rhododendron trial 2001. This trial was conducted in a block of field-grown *Rhododendrons* 'P.J.M.' in a commercial nursery. These plants were transplanted from #1 containers to the field in late May 2001. The insecticide treatments were applied November 1 or 5 when the grubs were large (third instar) and soil temperature was relatively low 8.9C (48F), which were less than ideal conditions (small grubs and warm soil, >15.6C, (60F)). The soil was a Tyner loamy sand (5).

Because the intact root balls were dense, we decided that applying insecticide directly into the root zone provided the highest probability for success. To that end, we tested three experimental applicators for delivering insecticide to the root zone. The experimental design was completely randomized. There were four treatments, which consisted of three experimental applicators applying Dursban TNP and an untreated control with 10 single-plant replications per treatment. One treatment was a LESCO root feeder (#013873, LESCO, Inc., Rocky River, OH) (operated at 20–30 psi) with a flow meter added (Fig. 1a). The nozzle was pointed with lateral holes about 1 cm from the tip, which discharged a stream of solution in four directions. During application the nozzle was pushed into the ground near the base of the plant (Fig. 1a) and delivered material directly to the root-zone. We also tested a nozzle custom designed by the grower (hereafter referred to as the grower nozzle) to fit a hand-gun sprayer (Universal 4500# PSI Spray Gun and 36 in (91.4 cm) Universal Insulated Wand, Universal™ Pressure Washer Parts and Accessories) (Fig. 1d). The nozzle was also pointed with lateral holes about 1 cm from the tip (Fig. 1b) that discharged solution in four directions. During application this nozzle was also pushed into the ground near the base of the plant (Fig. 1b) and delivered material directly to the root-zone. The LESCO root-feeder and grower nozzle treatments were applied at 30 and 50 psi, respectively, in two injection sites per

plant (3 seconds each on opposite sides of the plant) to deliver about 237 ml (8 oz) of solution. The third delivery system tested was a high-pressure hydraulic-jet spray nozzle with a rubber splash guard (200 psi) (hereafter referred to as the hydraulic-jet) that attached by a quick-coupler (Fig. 1c) to the same hand-gun sprayer (Fig. 1d) as the grower nozzle. The hydraulic-jet delivered a high-pressure stream of material from the soil surface (Fig. 1c), which then penetrated the soil about 5 cm (2 in). From that point the solution soaked into the root zone. The hydraulic-jet required 4 sites per plant and took 15 seconds to deliver about 237 ml (8 oz) of solution at 200 psi. The solution of Dursban TNP (chlorpyrifos) applied by all applicators was based on 907 g active ingredient (2 lb ai) in 378.5 liters (100 gal) of water, which is the rate for drenching containerized plants. Fifteen healthy plants were left untreated for comparison. On November 14, 2001, ten plants from each treatment were evaluated by digging the plants from the ground, breaking the root balls apart, and examining them carefully for live and dead larvae.

Hemlock trial 2002. This trial was conducted in a block of field-grown Eastern hemlocks in a commercial nursery. Because we had success against EC with treatments of Dursban TNP injected into the soil in 2001, we recommended that treatment to the hemlock grower. This grower allowed us to use some of the trees to test various rescue treatments. The site was about 0.8 ha (2 A) with Red Hook sandy loam soil (5). The hemlocks were about 25–30 cm (10–12 in) tall (when planted), bare-root, and planted in the field in late May 2002.

The experimental design was completely randomized and had five treatments with 15 single-tree replications per treatment. One treatment was Dursban TNP applied subsurface by the grower using an applicator similar to the grower nozzle in the rhododendron trial (Fig. 1b). The solution of Dursban TNP (chlorpyrifos) applied was based on 907 g active ingredient (2 lb ai) in 378.5 liters (100 gal) of water, which is the rate for drenching containerized plants. This treatment was applied at 50 psi in four injection sites per tree for about 2 seconds per site to deliver about 355 ml (12 oz) per plant. The four other treatments were a Dursban TNP drench with a shallow trench (ca. 30 cm (12 in) diameter) dug around each tree, a Dursban TNP drench with a straight trench (shallow) on each side of the trees (ca. 30 cm (12 in) apart) parallel to the rows, a Dylox 80 T & O (trichlorfon) drench with a shallow trench (ca. 30 cm (12 in) diameter) dug around each tree, and an untreated control. The shallow trenches were used to prevent surface run-off of the drenches. The rate of the Dursban TNP drenches was based on 907 g (2 lb) active ingredient in 378.5 liters (100 gal) of water, which is the rate for drenching containerized plants. The rate of the Dylox 80 T & O drench was 680.4 g (1.5 lb) active ingredient in 378.5 liters (100 gal) of water, which is the rate for surface treatments of turf. Drenches were applied at 355 ml (12 oz) of solution per tree. The drench treatments were applied September 24 and the subsurface treatment was applied September 27. All treatments were evaluated October 10. The hemlocks at this site had been planted bare-root. Consequently, for evaluation the trees were dug and the soil was dislodged from the roots then the soil and roots were examined carefully for grubs, and then the trees were replanted.

For both trials, mean numbers of healthy or sick+dead grubs per plant were computed and the data analyzed by analysis of variance (7). Grubs were considered sick if they

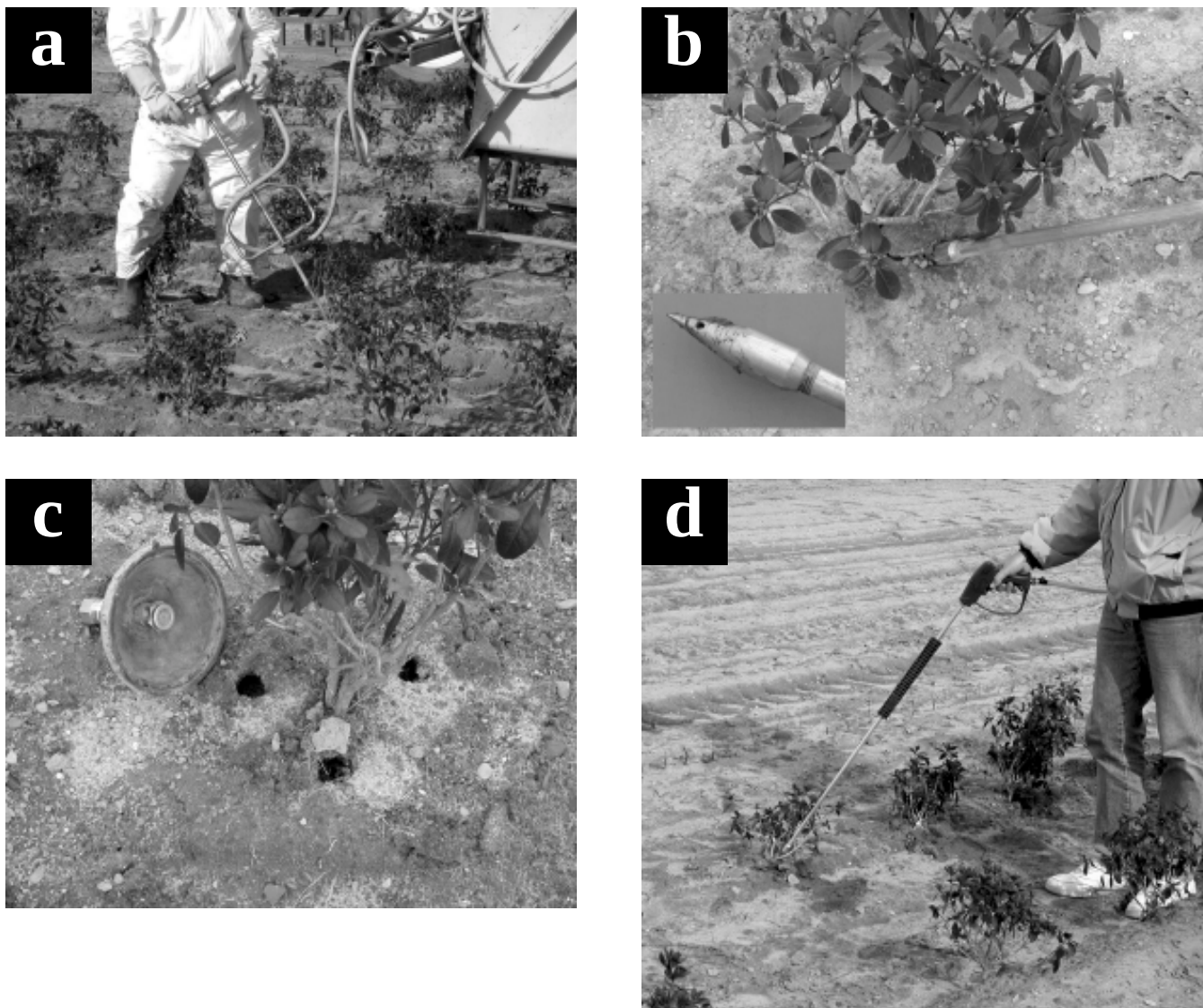


Fig. 1. Various applicators used to make subsurface treatments of insecticides against scarab grubs: a) LESCO root-feeder, b) grower nozzle, c) hydraulic-jet, d) high-pressure hand-gun sprayer.

were limp, could not hold a C-shape, crawl, or burrow when placed on the surface of loose soil. Variances were not homogeneous in either trial, therefore, the data were square-root transformed ($\sqrt{x+0.5}$) before analysis. Following significant ANOVA, comparison of treatment means of transformed data was performed by LSD (7).

Results and Discussion

In pretreatment surveys of the rhododendrons and hemlocks, dying and wilted plants were generally devoid of fibrous roots, and the stems were often partially girdled (Fig. 2a and b). Only EC grubs were found in both trials. Grubs were rarely found beneath rhododendron plants devoid of fibrous roots, and only occasionally under similarly damaged hemlock plants. However, plants of both species with fibrous roots contained grubs in almost all cases. Apparently, after consuming all of a plant's fibrous roots, the grubs moved to a new plant. There was no other vegetation in these fields,

thus, the rhododendrons and hemlocks were the only hosts available to grubs.

Rhododendron trial 2001. Insecticides applied using all three application techniques significantly reduced numbers of EC compared to untreated plants (Table 1), but there were no differences among the application methods. Healthy EC grubs were found in the root zones of all untreated plants except one. Almost all grubs in the insecticide treated plants were either sick or dead.

Any healthy grubs present (pre- and post-treatment samples) were generally on the periphery of the root zone or deep inside directly under the crown. Grubs tended to be on the periphery of root zones where little or no feeding damage was detected, which made it appear as if the plant was recently colonized. When grubs were inside the root zone tunneling and feeding injury was frequently visible on the outside. The severity of the damage caused by EC to the plants in this nursery was unexpected because EC damage to field-

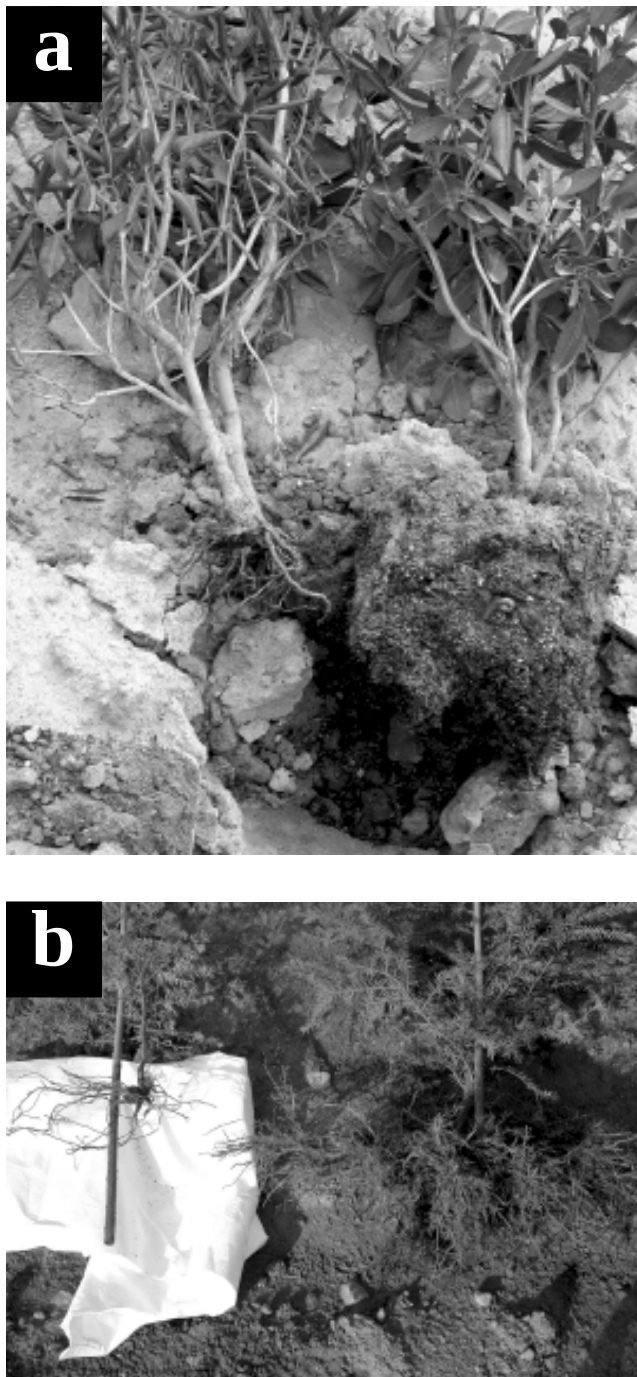


Fig. 2. Examples of damage to roots of rhododendron (a) and hemlock (b) caused by feeding of European chafer grubs. The plants on the left in each photo are damaged.

grown rhododendron had not been reported previously. During the pretreatment survey and then when this trial was evaluated, no more than 3 grubs were found in a plant. In addition, only 1 or 2 grubs were often present in plants with severely damaged roots.

Hemlock trial 2002. The Dursban subsurface, circular-trench drench, and Dylox drench treatments significantly reduced the number of grubs per plant compared to untreated trees and the Dursban straight-trench drench treatments (Table

Table 1. Mean numbers of European chafer grubs in field grown PJM rhododendrons treated with Dursban applied by various applicators 2001

Applicator	Applicator type	Mean (SE) grubs per plant ^a	
		Healthy	Sick + Dead
LESCO root feeder	root zone insertion	0.0 (0.0)b	1.1 (0.3)a
grower nozzle	root zone insertion	0.1 (0.1)b	0.5 (0.2)ab
Hydraulic-jet	surface	0.1 (0.1)b	0.6 (0.3)ab
Untreated		1.8 (0.3)a	0.0 (0.0)b
<i>F</i>		27.5	3.5
<i>df</i>		3,36	3,36
<i>P</i>		<0.0001	0.03

^aThe actual means (not transformed) and standard errors (SE) are presented. The *F* and *P* values are for the transformed ($\sqrt{x+0.5}$) data. Numbers within columns followed by the same letter are not significantly different *P* ≤ 0.05 (Fisher's LSD, α = 0.05).

2). Healthy grubs were found in all untreated trees with numbers ranging from 1–6. Any healthy grubs present were found in the soil directly under the roots, in the root zone, or at the base of the stem just below the soil surface. Only two of the trees in the Dursban subsurface treatment had healthy grubs (one in each tree). Sick and/or dead grubs were found in each insecticide treatment (≥20% of the trees). No sick or dead grubs were found in the untreated trees.

Results from the hemlock trial suggest that EC grubs can severely damage young trees quickly. Most damage is caused by the third instar grubs (8). In 2002, third instar EC were first detected in northern Ohio on August 20. We were notified of the problem in the hemlock field September 17. At that time, many trees were stunted and yellowed, with no fibrous roots.

In 2001, the trial was conducted under unfavorable conditions. The soil was cold (8.9C (48F)) and the grubs were large (third instar), and yet the treatments were effective. The soil temperatures were more favorable (20C (68F)) in 2002, but again the grubs were large (third instars). The data from both years indicate that rescue treatments against large EC grubs can be effective during fall when insecticide is injected directly into the root zone where the grubs are feeding. The

Table 2. Mean numbers of European chafer grubs in field-grown hemlock, a comparison of various rescue treatments 2002.

Applicator	Application type	Mean (SE) grubs per plant ^a	
		Healthy	Sick + Dead
Dursban TNP	subsurface treatment	0.1 (0.1)c	0.9 (0.5)b
Dylox 80SP	surface drench-CT	0.8 (0.5)bc	1.7 (0.5)a
Dursban TNP	surface drench-CT	1.4 (0.4)b	0.7 (0.3)b
Dursban TNP	surface drench-ST	2.8 (0.7)a	0.5 (0.2)b
Untreated		2.6 (0.5)a	0.0 (0.0)b
<i>F</i>		8.2	4.2
<i>df</i>		4,70	4,70
<i>P</i>		<0.0001	0.004

^aThe subsurface treatment applicator was inserted into the root zone; CT represents circular trench; ST represents straight trench.

^bThe actual means (not transformed) and standard errors (SE) are presented. The *F* and *P* values are for the transformed ($\sqrt{x+0.5}$) data. Numbers within columns followed by the same letter are not significantly different *P* ≤ 0.05 (Fisher's LSD, α = 0.05).

subsurface technique was faster on a per plant basis than the drench technique we used. The drenches would have been faster if trenches were not used. However, in preliminary tests the insecticide solution flowed from the target site when a trench was not used. Furthermore, Dursban was more effective when applied subsurface than on the surface. Because Dursban adsorbs to organic matter, surface drenches do not generally penetrate the soil well (10). Subsurface application may allow such pesticides to be used effectively against subterranean pests of ornamental plants.

All subsurface treatments were applied for us by the growers. Initially, we expected the subsurface techniques would be too time consuming to use on a commercial scale. However, in both years growers were willing to treat ≥ 0.8 hectares (≥ 2 acres) using a subsurface technique because they believed it was the best method to prevent further loss of plants.

The application techniques described here may not be appropriate for all situations. The rhododendrons were small with root zones about #1 container size, and consisted primarily of roots and container media. The hemlocks were also small, with root systems of healthy plants about twice the size of the rhododendrons. It might be difficult to achieve sufficient coverage of larger root zones or in less porous soils. However, complete coverage of the root zone might not be necessary if treatments are applied earlier in the season when soil temperatures are higher and grubs smaller. Grubs should be more active in warm soil making them more likely to contact treated soil. Further research is required to determine under which conditions these delivery systems are most effective, and to evaluate other types of nozzles and insecticides.

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