Residual Toxicity of Imidacloprid to Hawthorn Lace Bug, *Corythuca cydoniae*, Feeding on Cotoneasters in Landscapes and Containers[1]

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Abstract

Cotoneasters are important and valuable landscape plants. They are severely attacked by hawthorn lace bug (*Corythuca cydoniae)* in landscapes and nurseries. Imidacloprid has a wide range of activity against many kinds of insect pests. We were interested in determining if cotoneasters treated with soil applications of imidacloprid in landscapes and containers remained toxic to hawthorn lace bugs for more than one growing season. Cotoneasters planted in landscapes were less damaged by lace bugs in the year that imidacloprid was applied and in the following year. We suspect that residual toxicity of leaves of cotoneasters particularly to the nymphs of lace bugs as the cause. Cotoneasters grown in containers demonstrated toxicity to lace bugs for almost 800 days after the application of imidacloprid to the soil. These data greatly extend the known period of efficacy for imidacloprid in controlling hawthorn lace bug on cotoneasters. Clearly, lace bugs are controlled for a minimum of two years. By reducing the need for repetitive applications, a single application of imidacloprid can reduce time, labor and material costs associated with managing this important pest of cotoneasters.

Index words: landscape plants, container production, pest management, neonicotinoid insecticide.

Species used in this study: cotoneaster, *Cotoneaster salicifolius* (Franch); *Cotoneaster dammeri* (Schneid); hawthorn lace bug *Corythuca cydoniae* (Fitch).

Insecticide used in this study: Merit (imidacloprid), Marathon (imidacloprid), 1-[(6-chloropyridin-3-yl) methyl]-N-nitro- 4,5-dihydroimidazol-2-amine.

Significance to the Nursery Industry

Cotoneasters are important woody shrubs produced in containers and widely planted in a variety of landscapes settings, and they are frequently damaged by the hawthorn lace bug. Imidacloprid is a valuable insecticide used to control a variety of insect pests in landscapes and nurseries. We demonstrated that a single soil application of imidacloprid to *Cotoneaster salicifolius* planted in landscape beds provides protection from hawthorn lace bug well into the second growing season. *Cotoneaster dammeri* growing in containers treated with imidacloprid remained toxic to hawthorn lace bug well into the third growing season following a single soil application. Due to its long residual activity, imidacloprid can reduce the need for repetitive applications, thereby reducing, time, labor and material costs associated with managing hawthorn lace bug.

Introduction

Imidacloprid was the first neonicotinoid insecticide introduced to the nursery production and landscape industries. It has become widely used owing to its range of activity against key pests including leaf beetles (9, 12), Japanese beetles (4), lace bugs (6), aphids (12), scales (5, 12), psyllids (17), adelgids (3, 14, 16), periodical cicadas (1), flatheaded borers (7), and leafminers (2). It is noteworthy that imidacloprid is not always effective against scales (8). Most studies of imidacloprid efficacy have focused on the toxicity, pest population reductions, or foliage protection of imidacloprid within a time scale of weeks or months after application. Notable exceptions include the work of Sclar and Cranshaw (12), Young (17), Lawson and Dahlsten (9), Webb et al. (16), and Ahern et al. (1).

In 2002, a landscape maintenance firm in Maryland raised an inquiry regarding the residual activity of imidacloprid applied to landscape plants. Their clients had numerous landscape beds heavily planted with willow leaf cotoneaster (*Cotoneaster salicifolius),* a species susceptible to damage by the hawthorn lace bug. Hawthorn lace bug is a native insect that attacks members of the Rosaceae but it has become especially problematic on cotoneasters (10, 11). To control this pest the management firm applied imidacloprid to the soil in February 2001. During the growing season that imidacloprid was applied, landscape managers noticed that treated plants bore no signs of infestation while untreated plants nearby were heavily infested and damaged. The landscape management firm wanted to know if imidacloprid remained active in the foliage of *C. salicifolius* for more than a single growing season.

By 2002 imidacloprid had become widely recommended for controlling a variety of pests in production nurseries. Lace bugs are key pests in wholesale and retail nurseries where they attack valuable shrubs such as cotoneasters growing in containers (10, 11). To date there are no published accounts of the activity of imidacloprid in controlling hawthorn lace bugs on containerized cotoneaster.

The objectives of our study were threefold. We had two objectives for cotoneasters planted in landscapes. First, we wanted to verify the observation that lace bugs and their damage were rare on plants treated with imidacloprid compared

[1]Received for publication September 11, 2006; in revised form November 30, 2006. The authors thank Steven Sullivan and the Brickman Group for providing information and sites to conduct the landscape study. We thank Kevin Brown and the Department of Physical Plant, University of Maryland, for their assistance. Bayer Environmental Science provided imidacloprid for these studies. The National Research Initiative of the USDA Cooperative State Research, Education and Extension Service, Grant Number 2005-35302-16269 provided partial support of this project.

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to plants in untreated beds. Second, we wanted to determine if treated foliage of *C. salicifolius* remained toxic to hawthorn lace bug for periods of time exceeding one year. The third objective involved containerized cotoneasters. We were interested in determining how long containerized *C. dammeri*, 'Bearberry cotoneaster', remained toxic to hawthorn lace bugs.

Materials and Methods

Frequency of lace bugs on cotoneaster following imidacloprid applications in landscapes. The effect of imidacloprid on the frequency of lace bug infestations was investigated by surveying landscape plantings of cotoneaster in central Maryland. We worked with a commercial management firm to identify cotoneaster plantings treated with imidacloprid. This firm managed landscapes at several corporate campuses. Between February 8 and 18, 2001, seven landscape beds of *C. salicifolius*, at two locations were treated with imidacloprid (Merit® 2.5 G) at the labeled rate of 42.5 g (1.5 oz) of imidacloprid per 1.2 m (4 ft) of shrub height. We identified four beds of *C. salicifolius* at two nearby locations that had not been treated with imidacloprid to serve as untreated controls.

Between September 12 and October 10, 2002, cotoneasters were examined for the presence or absence of lace bugs and their injury. Injury included coarse or fine stippling and infestation signs including feces, eggs and chorions, and exuvae. Five plants were examined in each treated and untreated bed. We examined ten terminal leaves on five branches evenly spaced around the perimeter of each plant and recorded the presence of lace bugs or signs of their injury on each plant. Thirty-five treated and twenty untreated plants were sampled.

To compare the frequency of lace bug infestations on cotoneasters in landscapes, the number of infested plants in a sample of five was compared for treated and untreated beds. Variance in the number of infested plants was not homogeneous and homogeneity of variance could not be achieved through transformation of the data. Therefore, the number of plants infested with lace bugs was compared with a Kruskal-Wallace nonparametric analysis of variance (13, 18).

Residual activity of imidacloprid in landscape plants. The residual activity of imidacloprid in landscapes was evaluated by comparing the toxicity of treated and untreated cotoneasters to hawthorn lace bug nymphs and adults. Toxicity of the plants was assessed by exposing third instar nymphs and adults to foliage from treated and untreated plants. On September 14, 2002, we collected leaves from cotoneasters in three treated and three untreated landscape beds described in the previous section. Approximately 30 leaves were removed from one plant in each bed. Leaves were placed in plastic bags, stored on ice in a cooler, and transported to the laboratory. Within 2 h of excision six to eight leaves were placed in experimental arenas that consisted of a large Petri plate (100 × 15 mm) (3.94 × 0.59 in) BD Falcon® lined with a moistened filter paper (Whatman® 1). Prior to the bioassay any lace bugs were removed from leaves. Hawthorn lace bugs used for the bioassays were obtained from naturally infested, untreated beds of cotoneaster at the College Park campus of the University of Maryland, College Park, MD. The lace bugs were transferred from infested clippings to experimental arenas using a paintbrush. Cohorts of 10 lace bug nymphs and adults were added to separate arenas. The experimental arenas were maintained in a Percival® growth chamber at 24C (75F) and 16:8 light:dark cycle. Nymphs and adults were observed each day for five days. Three replicates of each treatment were used in this study.

Survival of the lace bugs over a period of 5 days was recorded. The response variable was the number of lace bug nymphs and adults alive after five days of exposure to treated or untreated leaves of cotoneaster. The survival of *C. cydoniae* nymphs and adults was evaluated using an analysis of variance for a factorial design with two life stages, adults and nymphs, and two levels of treatment, treated and untreated. (13, 18).

Residual activity of imidacloprid in containerized plants. The study took place at the Research Greenhouse Complex at the University of Maryland, College Park, MD, from June 2003 to September 2006. Ten containerized cotoneaster, *Cotoneaster dammeri*, were used in the experiment. Plants were purchased from a retail nursery in #1 (0.98 gal, 3.71 liter) containers in June 2002. The plants were transferred to #3 (2.94 gal, 10.99 liter) containers and potted in Metromix® 510 soil in June 2003. All plants were approximately 0.6 m (2 ft) in height at the commencement of the study. They were kept in an outdoor cold frame prior to and throughout the experiment. Throughout the duration of the study, plants were watered twice daily or as needed with a hand-held hose until discharge of water from the bottom of the container was observed. Plants were fertilized twice each growing season, once in May and again in July with slow-release fertilizer Nutricote® (N–P–K: 18–6–8). The cotoneasters were pruned twice during the study, and their height was 0.76 m (2.5 ft) at the end of the experiment. Five plants were randomly assigned to the imidacloprid treatment and the five remaining were left as untreated controls. The plants in the imidacloprid treatment received an application of Marathon® 60 WP at high-rate label dose (0.5 g (0.02 oz) of Marathon® 60 WP in 1 liter (0.26 gal) of water) on June 20, 2003. The control plants received 1 liter (0.26 gal) of water on the same day. Irrigation was suspended on all plants for three days following the application of imidacloprid to treated plants.

To assess toxicity of the cotoneaster foliage, one terminal branch approximately 10.2 cm (4 in) was excised from each of the 5 treated and 5 untreated plants and transported to a laboratory in a cooler filled with ice. The excised shoots were placed in bioassay arenas that consisted of a large Petri plate (100 × 15 mm) (3.94 × 0.59 in) BD Falcon® lined with a moistened filter paper (Whatman® 1).

We exposed third instar nymphs of hawthorn lace bugs to foliage from treated and untreated plants. We used nymphs for this study as they were more sensitive to intoxication by imidacloprid than adults as determined by the study described above. Hawthorn lace bug nymphs were obtained as described previously. The lace bugs were transferred from infested clippings to experimental arenas using a paintbrush. The filter paper was moistened and/or changed every day as needed. Nymphs were observed each day for five days and nymphs found off the plant material were moved back onto the foliage. The experimental arenas were maintained in a Percival® growth chamber at 24C (75F) and 16:8 light:dark cycle. Survival of the nymphs was recorded after a period of 5 days. The response variable was the number of nymphs alive after five days of exposure to treated or untreated cotoneaster leaves.

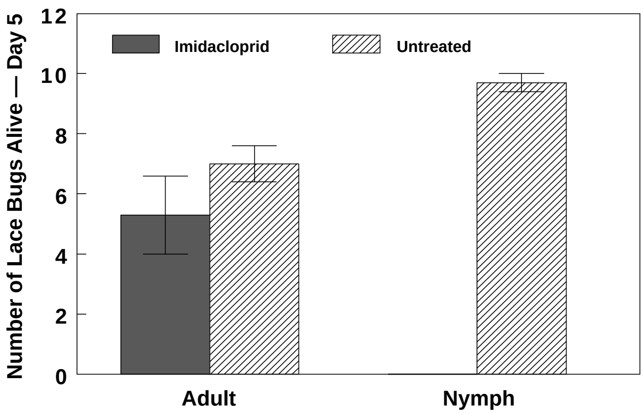

Fig. 1. Comparison of toxicity of leaves of *Cotoneaster salicifolius* planted in landscapes treated and not treated with a single application of imidacloprid in February 2001 to hawthorn lace bug adults and nymphs, *Corythuca cydoniae*. Leaves were assayed in September 2002. Bars represent means and vertical lines are standard errors.

Bioassays coincided with the dates when hawthorn lace bug nymphs were first common on cotoneasters each spring and were repeated at intervals of approximately one month. In 2003 and 2004 cotoneasters were assayed four times for toxicity. In 2003, bioassays were conducted on June 29, July 25, August 16, and September 20. In 2004 bioassays were conducted on June 11, July 11, August 6, and September 7. In 2005 and 2006 two bioassays for toxicity were conducted. In 2005 bioassays were conducted on June 11 and August 26 and in 2006 bioassays were conducted on June 6 and August 30. For each date that bioassays were conducted each treatment was replicated five times.

On each date, data were examined for normality using a Shipiro-Wilk test (13, 18) and homogeneity of variance using a Bartlett's test (13, 18). When assumptions were met for analysis of variance, the number of surviving lace bugs was compared among treatments with a one-way analysis of variance (13, 18). When assumptions for an analysis of variance were not satisfied the number of surviving lace bugs was compared with a Kruskal-Wallace nonparametric analysis of variance (13, 18).

Results and Discussion

Frequency of lace bugs on cotoneaster following imidacloprid applications in landscapes. Cotoneasters treated with imidacloprid were significantly less likely to house detectable levels of *C. cydoniae* than those untreated ($c^2 = 10.0$, df = 1, $P = 0.002$) approximately 19 months later. In landscape beds treated with imidacloprid, no infestations of lace bugs were detected. This contrasted with the detection of lace bugs on every plant in untreated beds. This finding confirms observations of the landscape managers that cotoneasters remain free of lace bugs and their damage well into the second growing season after an application of imidacloprid is made.

Residual activity of imidacloprid in landscape plants. Application of imidacloprid interacted with the life stage of the target pest in a significant way ($F = 28.8$; df = 1,8; $P = 0.001$) (Fig. 1). Survival of *C. cydoniae* adults was similar when exposed to leaves from treated and untreated plants in the second season following the application of imidacloprid. However, survival of *C. cydoniae* nymphs was zero on treated plants and almost 100% on untreated ones (Fig. 1). This result probably explains at least in part the absence of lace bugs on cotoneasters in the second growing season following the application of imidacloprid.

We noticed that shortly after adults and nymphs of *C. cydoniae* were added to arenas with foliage treated with imidacloprid, they fed little, as evidenced by a lack of stippling on the leaves and the absence of the production of frass. Lace bugs were often observed on filter paper lining the arena rather than on foliage. In some cases they exhibited trembling, loss of coordination, and, finally, cessation of movement and death. These symptoms are common for insects intoxicated with imidacloprid (15).

Residual activity of imidacloprid in containerized plants. On each date in 2003 cotoneasters treated with imidacloprid supported significantly fewer lace bug nymphs than untreated plants (June 29, $P < 0.004$; July 25, $P < 0.004$; August 16 $P < 0.01$, and September 20, $P < 0.0001$) (Fig. 2). The same trend held true for 2004 where on each date significantly fewer lace bug nymphs survived on treated compared to untreated plants (June 11, $P < 0.0001$; July 11, $P < 0.0002$; August 6 $P < 0.0005$, and September 7, $P < 0.005$) (Fig. 2). Despite greater mortality on treated plants, in June, July, and August, some survival was noted on plants treated with imidacloprid in all years. Survival was low on treated plants, however, and ranged from about 10 to 28% of the survival of nymphs on corresponding untreated plants. On the first date plants were assayed in 2005, June 11, they remained highly toxic to lace bug nymphs ($P < 0.0001$) (Fig. 2). However, by the second date, August 26, some of the toxicity was lost even though survival remained significantly lower on treated plants ($P < 0.027$) (Fig. 2). Treated plants remained about 38% more toxic than untreated ones. By the first sample date in 2006, no difference in survival of lace bugs was detected between treated and untreated cotoneasters ($P > 0.05$) (Fig. 2). Lace bug nymphs survived very well on treated and untreated plants on both dates bioassays were conducted.

The efficacy of imidacloprid in controlling hawthorn lace bug is not without precedent. Gill et al. (6) found complete control of hawthorn lace bug on *Crataegus viridis* treated with soil applications or trunk injections of imidacloprid. What is surprising is the length of the residual toxicity of imidacloprid in shrubs in landscapes and containers. Others have found prolonged periods of activity of imidacloprid in woody plants in landscapes. Sclar and Cranshaw (12) found imidacloprid to be lethal to European elm scale, *Gossyparia spuria* 15 months after soil injections of imidacloprid. Soil drenches of imidacloprid were lethal to elm leaf beetle, *Xanthogaleruca luteola* for more than 12 months (12). Young (17) reported significant reductions in the number of red gum lerp psyllids, *Glycaspis brimblecombei*, 15 months after the injection of imidacloprid into the trunk of red gum trees. Lawson and Dahlsten (9) reported significant mortality of elm leaf beetles exposed to leaves from elms injected with imidacloprid through the bark at 33 days after the treatment but toxicity was lost by the 382 day after the application of imidacloprid. Webb et al. (16) found Eastern Hemlocks, *Tsuga canadensis*, to be free of hemlock woolly adelgid, *Adelges tsugae*, 816 days after the application of imidacloprid to the soil despite the fact that in the same landscape, trees infested with adelgids were nearby. Frank et al. (4) found linden trees

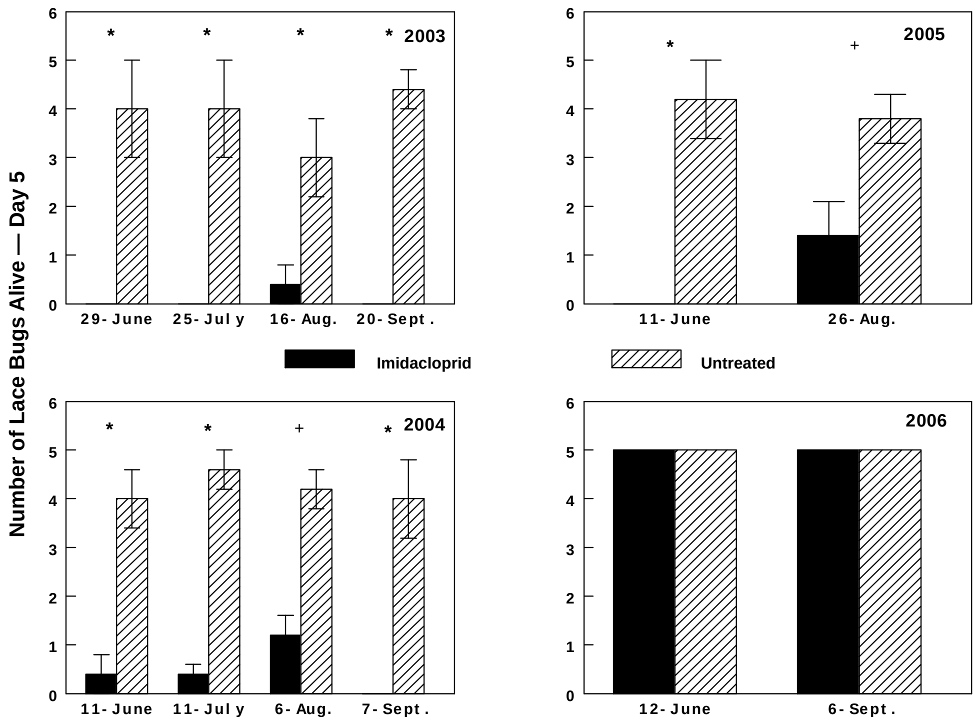

Fig. 2. **Comparison of toxicity of leaves of containerized *Cotoneaster dammeri* treated and not treated with a single application of imidacloprid on June 20, 2003, to hawthorn lace bug, *Corythuca cydoniae*. Bars represent means and vertical lines are standard errors. An asterisk (*) above a pair of means indicates that survival differed between treated and untreated plants by a Kruskal-Wallace test and a plus sign (+) indicates significance determined by an Analysis of Variance.**

treated with a soil drench of imidacloprid sustained lower levels of defoliation by Japanese beetles more than 400 days after the application of the insecticide.

Previous findings along with results of this study provide strong evidence of long-term activity of imidacloprid in several trees and shrubs. Imidacloprid applications in landscapes and nurseries provide growers with lasting and efficacious control of key pests, thereby reducing the need for frequent re-applications. Fewer applications mean reduced costs and less risk of collateral problems associated with pesticide use such as exposure of non-target organisms and environmental contamination.

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