Borate and imidacloprid treatment of ash logs infested with the emerald ash borer

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Abstract

As of January 2006, portions of Indiana, Michigan, Ohio, and Ontario were infested with the emerald ash borer (EAB), *Agrilus planipennis*, a destructive exotic Asian beetle that feeds within the inner bark of ash (*Fraxinus*) trees. This project evaluated borate (dissodium octaborate tetrahydrate) and imidacloprid to sanitize EAB-infested logs, which would then facilitate log transport to mills outside the quarantine zones. EAB-infested logs were cut in winter and then spray- or dip-treated with either borate (1% to 5.5% BAE [boric acid equivalents]) or imidacloprid (0.01% to 0.05%). Treated logs were maintained indoors and evaluated for EAB adult emergence. Results indicated that low concentrations of borate (1% to 4%) were not effective at reducing EAB adult emergence. The highest borate concentration tested (5.5% BAE) significantly reduced EAB emergence for dip-treated logs but not for spray-treated logs. All imidacloprid concentrations, for both spray and dip treatments, completely controlled EAB adult emergence.

The emerald ash borer (EAB), *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae), is a destructive Asian beetle that attacks and kills ash (*Fraxinus*) trees. EAB is native to northeastern China, neighboring Mongolia and Russia, Korea, Japan, and Taiwan (Liu et al. 2003). EAB was first found in southeastern Michigan and neighboring Ontario in 2002 (Haack et al. 2002). As of January 2006, EAB had expanded its range in both Michigan and Ontario, as well as into Indiana and Ohio (Haack 2006). EAB has been found to infest and kill all native species of ash in the Great Lakes area, including *Fraxinus americana* (white ash), *F. nigra* (black ash), *F. pennsylvanica* (green ash), and *F. quadrangulata* (blue ash) (Cappaert et al. 2005, Poland and McCullough 2006).

The biology of EAB consists of four life stages, which is typical of beetles. Adults emerge in early summer, feed on leaves, and lay eggs on the bark surface along the trunk and branches of ash trees. After hatching, larvae tunnel through the bark into the cambial area where they feed, creating S-shaped galleries. Fully developed larvae construct pupal chambers in the outer bark or the outer sapwood in fall. In late spring and early summer of the next year, larvae transform to pupae and then to adults. The new adults chew their way through the bark and the cycle is renewed. Translocation in both the inner bark and outer sapwood is severely restricted by EAB feeding galleries, which results in crown dieback and eventual tree death after 3 to 4 years of successive infestation (Cappaert et al. 2005, Poland and McCullough 2006).

EAB has had a devastating impact on the ash resource. In Michigan alone, 5 million to 7 million ash trees were estimated to be either infested or killed by EAB as of 2002, and over 15 million by 2004 (Cappaert et al. 2005). It is estimated that more than 1.2 billion ash trees occur on timberland in the three currently infested states of Indiana, Michigan, and Ohio (Miles 2006). Nationwide, more than 8 billion ash trees grow on timberland and have an undiscounted compensatory value estimated at $282 billion (USDA APHIS 2003). Similarly, the

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Table 1. — Borate and imidacloprid concentrations evaluated to reduce EAB emergence from infested ash logs maintained indoors.[a]

Insecticide		Concentrations tested			
		------------------(%)------------------			
Borate	DOT	6.60	4.90	2.45	1.22
	BAE	5.52	4.10	2.05	1.02
Imidacloprid		0.05	0.03	0.02	0.01

[a]DOT = dissodium octaborate tetrahydrate; BAE = boric acid equivalent.

undiscounted value of the nation's urban ash trees is estimated at $20 to $60 billion (USDA APHIS 2003).

The current EAB management strategy emphasizes containment of EAB populations primarily along the borders of Michigan's Lower Peninsula, with active eradication efforts occurring in Indiana, Ohio, and the Upper Peninsula of Michigan (Poland et al. 2006). As a consequence, tens of thousands of ash trees have been cut, primarily in urban areas. Most trees have been chipped and then burned in cogeneration plants for energy. A relatively small volume of ash wood has been milled owing to the existence of few mills within the currently infested areas and the U.S. EAB federal quarantine that regulates movement of ash logs to areas outside the quarantine zones (USDA APHIS 2003).

Numerous EAB studies are currently underway, addressing topics such as biology, dispersal, attractants, host range, natural enemies, tree resistance, trapping methods, control methods, and survey techniques (Cappaert et al. 2005, Mastro and Reardon 2005, Nzokou et al. 200_). There is an urgent need to develop sanitization treatments to allow greater movement and utilization of the ash resource so that value-added products can be developed. The goal of this project was to investigate the performance of borate (dissodium octaborate tetrahydrate [DOT]) and a technical grade of imidacloprid for sanitization treatment of EAB-infested ash logs, which would facilitate log movement to areas outside the quarantine zone.

Experimental

Log harvesting and preparation

Eight green ash trees were harvested from Kensington Metro Park near Brighton, Michigan, in early winter 2004, when most EABs were overwintering as fully developed larvae. The trees were checked for EAB infestation by removing the bark at breast height and confirming the presence of current-year galleries and larvae. Only heavily infested trees were harvested.

The bole of each tree was cut into eight 1-m-long logs and labeled according to their vertical position within the tree. Each log was further divided into two 50-cm-long bolts, one used as an untreated control, and one assigned to a treatment. Four to five replicates and their matching untreated bolts were evaluated at each chemical concentration. The bolts were transported to the Department of Forestry at Michigan State University for treatment and subsequent EAB rearing.

Treatments

All treatments were completed within 1 week of tree harvesting. Four concentrations of borate were evaluated (1.2% to 6.6%; **Table 1**). When expressed as boric acid equivalents (BAE) the borate concentrations varied from 1.02 to 5.52 percent (**Table 1**). The borate solutions were obtained by diluting the appropriate weight of the wettable powder Tim-bor® Professional (Nisus Corporation; 98% DOT) (Anon. 2004) in water at room temperature.

Figure 1. — Cardboard rearing tube with plastic lid, screening, and collection cup with EAB adults visible.

The imidacloprid solutions were prepared in a similar way by using a technical grade of imidacloprid wettable powder called Preventol® TM (Bayer Group; 98.4% imidacloprid). The four treatment solutions varied from 0.01 to 0.05 percent (**Table 1**).

Bolts were treated with one of four individual concentrations of borate or imidacloprid. For the spray treatments, bolts were placed in a plastic container to collect overflow and then all outer surfaces were thoroughly sprayed with a garden sprayer. For the dip treatment, bolts were completely immersed in the solutions for 4 hours. Dipped bolts were allowed to drain before placement in the rearing tubes. Only the highest and lowest concentrations of borate and imidacloprid were used as dip treatments (**Table 1**).

Rearing

All bolts were placed in individual cardboard rearing tubes with plastic lids at both ends. A circular hole was cut in one lid on each tube, and fine-mesh screening was glued over the hole. A small circular hole was then cut in the screening over which was glued the lid of a screw cup, with a similar sized hole. A screw cup was then attached to each lid. The screening allowed air circulation and light into the tube, and the mounted cups collected the EAB adults as they emerged (**Fig. 1**). The tubes containing bolts were maintained at ambient indoor conditions with constant lighting.

EAB adult emergence started after 35 days of incubation. The number of EAB adults emerging from each bolt was computed over the emergence period, which lasted a few weeks. Emerging adults were collected daily.

Data analysis

EAB adult emergence density (number of adults per m^2 of bark surface area) was calculated for each bolt based on bolt length, bolt diameter, and number of adults collected. Mean emergence density values were compared among treatments, using one-way analysis of variance (ANOVA, PROC GLM, SAS version 8) after log transformation to normalize the data.

Table 2. — Mean (±1 SE) EAB adult emergence density from borate and imidacloprid spray-treated ash logs maintained indoors.

Insecticide	Concentration	Treatment type	Mean emergence density[a]
Borate	5.52% BAE[b]	Spray (4)[c]	11.5 ± 2.8 A[d]
	4.10% BAE	Spray (4)	48.2 ± 25.6 A
	2.05% BAE	Spray (4)	80.2 ± 31.8 A
	1.02% BAE	Spray (4)	47.4 ± 16.5 A
	Control	Untreated (16)	78.0 ± 27.5 A
Imidacloprid	0.05%	Spray (4)	0.0 ± 0.0 B
	0.03%	Spray (4)	0.0 ± 0.0 B
	0.02%	Spray (4)	0.0 ± 0.0 B
	0.01%	Spray (4)	0.0 ± 0.0 B
	Control	Untreated (16)	69.4 ± 14.4 A

[a]Density = number of adults/m^2 of bark surface area.
[b]BAE = boric acid equivalent.
[c]Values in parentheses are number of bolts.
[d]Means (within insecticide treatments) followed by the same capital letter are not significantly different at $p = 0.05$ (Tukey multiple-range test).

If the ANOVA was significant at the 0.05 level, then the Tukey multiple-range test was performed to separate means.

Results

Spray treatments

Overall, no borate spray treatment significantly reduced EAB emergence density when compared with the untreated bolts (F = 0.95, df = 4, 27, $p = 0.449$; **Table 2**). In absolute terms, although not significantly different, bolts treated with the highest concentration of borate (5.52% BAE) had a relatively low average EAB emergence density (11.5 adults/m^2) compared with average emergence from the untreated bolts (78.2 adults/m^2). In some cases, EAB adults died as they chewed through the bark (**Fig. 2**). This appeared to be more common on treated bolts, but detailed notes were not recorded.

All four imidacloprid spray treatments significantly reduced EAB emergence density compared with the untreated bolts (F = 15.2, df = 4, 27, $p < 0.0001$; **Table 2**). In fact, no EAB adults emerged from any of the bolts that were sprayed with imidacloprid (0 adults/m^2), compared with an average EAB emergence density of 69.4 adults/m^2 for the untreated bolts (**Table 2**).

Dip treatments

With respect to the borate treatments, only the highest concentration (5.52% BAE) significantly reduced EAB emergence density (4.1 adults/m^2) when compared with the untreated bolts (71.4 adults/m^2; F = 15.8, df = 2,15, $p = 0.0002$; **Table 3**). In the case of imidacloprid, both concentrations tested resulted in complete EAB control (0 adults/m^2) compared with untreated bolts (28.8 insects/m^2; F = 12.0, df = 2,15, $p = 0.0008$; **Table 3**).

Conclusions

Borate and imidacloprid treatments were tested for their effectiveness in sanitizing EAB-infested logs. Borate concentrations of 1.02, 2.05, and 4.10 percent BAE did not reduce EAB emergence from treated bolts. The highest borate concentration tested (5.52% BAE) did reduce EAB emergence when bolts were dipped but not when sprayed, suggesting that borate concentrations higher than 5.52 percent BAE might

Figure 2. — Occasionally EAB adults died as they chewed through the bark, especially on treated logs.

Table 3. — Mean (±1 SE) EAB adult emergence density from borate and imidacloprid dip-treated ash logs maintained indoors.

Insecticide	Concentration	Treatment type	Mean emergence density[a]
Borate	5.52% BAE[b]	Dip (4)[c]	4.1 ± 2.4 B[d]
	1.02 BAE	Dip (5)	54.3 ± 15.2 A
	Control	Untreated (9)	71.4 ± 20.0 A
Imidacloprid	0.05%	Dip (5)	0.0 ± 0.0 B
	0.01%	Dip (4)	0.0 ± 0.0 B
	Control	Untreated (9)	28.8 ± 8.3 A

[a]Density = number of adults/m^2 of bark surface area.
[b]BAE = boric acid equivalent.
[c]Values in parentheses are number of bolts.
[d]Means (within insecticide treatments) followed by the same capital letter are not significantly different at $p = 0.05$ (Tukey multiple-range test).

lead to greater control. Both spraying and dipping with all concentrations of imidacloprid tested, resulted in complete EAB control. Apparently mortality results from ingestion of a lethal dose of pesticide as adults chew through the bark, given that many dead adults were found inside the bark or partially emerged in both the present study and other related studies (T.R. Petrice and R.A. Haack, unpublished data).

These results show promise for finding a simple chemical treatment that can sanitize EAB-infested ash logs and thereby facilitate movement of ash logs to areas where maximum value can be obtained from the raw material. These results, which were obtained indoors, indicated that the chemicals tested can be very effective. However, their effectiveness under outdoor conditions and at different seasons of the year needs further investigation to assess insecticidal persistence and to develop treatment and handling recommendations for infested ash logs. These topics are the focus of our current investigations.

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