

# Evaluation of Insecticides to Control Emerald Ash Borer Adults and Larvae

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## Summary of Research Conducted in 2003

### Objectives

We evaluated widely available insecticide products and application methods to assess their effectiveness in controlling emerald ash borer (*Agrilus planipennis* Fairmaire) (EAB). Our objectives were to:

- **Evaluate the ability of insecticides to control EAB adults.**

We caged adult beetles with leaves from treated and untreated (control) trees for 8-day bioassays to compare survival and leaf consumption. The bioassays were repeated at 2- to 3-week intervals in June and July using foliage collected from the trees at Kensington Golf Course (see study sites).

- **Evaluate the ability of insecticides to control EAB larvae.**

We removed “windows” of bark from the trunk and large canopy branches to quantify EAB larval density in treated and control trees. Samples were taken from at least 14 locations per tree and a minimum of 5,400 cm<sup>2</sup> (roughly 835 square inches) was examined. Larval sampling occurred from mid-September through December.

- **Assess persistence of insecticides over time.**

Data from the adult bioassays allowed us to assess the persistence of the insecticide products over the summer. In addition, we measured concentrations of imidacloprid in xylem sap collected from the trees at the Kensington Golf Course site (using a method called ELISA analysis) at 2- to 3-week intervals in June and July.

### Study Sites

Results of research conducted in 2002 showed that poor translocation in heavily infested trees limited the effectiveness of trunk-injected insecticides. In 2003, therefore, our insecticide research was conducted in sites with low to moderate EAB densities located in Washtenaw and Livingston counties. Exit holes and woodpecker holes occurred on at least a few trees at each site, but were not common. The ash trees we used at these sites were relatively healthy with

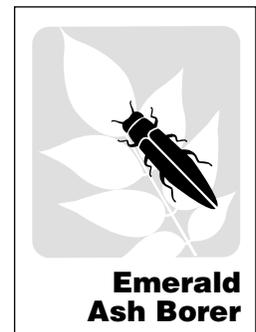
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## Evaluation of Insecticides to Control Emerald Ash Borer Adults and Larvae

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0 to 20 percent dieback (except for the St. Joe site where effects of dieback were part of the study). We selected trees of similar size and condition at each site and randomly assigned trees to be part of an insecticide treatment group or to be left as untreated controls. There were six to 12 trees per treatment at each site. All insecticide applications were made under nearly ideal conditions (i.e., good soil moisture, sunny weather, active transpiration). We sampled a total of 234 trees to assess control of EAB larvae (Table 1). Trees at two sites, Forsythe and Dartmoor, have not yet been destructively sampled to quantify EAB larval density. These trees were injected with imidacloprid and will be sampled in 2004 to determine if EAB control persists for two years. Trees at the St. Joe site were used to assess relationships between canopy condition and effectiveness of trunk-injected imidacloprid. Analysis of these data is in progress.

### Products and Application Methods

Below is a summary of the insecticide products and application methods that we tested in 2003. We also identify some advantages and disadvantages that we associate with specific products or application methods.

#### Soil injection – Imidacloprid Merit 75 WP

**Applied:** April 15-17.

**Rate:** 1.42 g AI per inch dbh (diameter at breast height, measured 1.4 m aboveground)

Injected in circular pattern around base of tree and again halfway to the dripline.

Minimum of four injection points in each circle per tree.

High pressure injection at 80 to 100 PSI.

Kioritz set to 5 ml per stroke.

**Pros:**

- Relatively quick to apply.
- No wounding or injury to tree.

**Table 1.** Tree diameter (measured at 1.4 m aboveground) and number of trees in EAB insecticide studies in 2003.

Study Sites	Average tree diameter		No. trees
Airport – East	3.9 inch	10.0 cm	36
Airport – West	4.4 inch	11.2 cm	50
Huron Hills GC	16.0 inch	40.6 cm	36
Law/Lands Park	13.8 inch	35.0 cm	30
Kensington GC	13.0 inch	32.9 cm	82
Forsythe	5.7 inch	14.5 cm	<i>2-year control</i>
Dartmoor	16.6 inch	42.1 cm	<i>2-year control</i>
St. Joe hospital	7.9 inch	20.0 cm	<i>dieback analysis</i>

- Little exposure for applicators.
- Relatively low toxicity to humans, birds and some groups of non-target insects (e.g., caterpillars).
- No drift problems.
- Little impact on non-target insects or other organisms that do not feed on ash.

**Cons:**

- Must be applied 4 to 8 weeks before EAB are active to assure uptake by roots and translocation through tree.
- Translocation may be poor if trees are unhealthy or were heavily injured in previous years.
- Adequate soil moisture and transpiration are needed for good uptake.

**Trunk injection – Imidacloprid Imicide**

**Applied:** May 20-22.

**Rate:** 3 ml Mauget capsules (10 percent AI). Number of capsules injected — dbh divided by 2.

**Trunk injection – Imidacloprid Pointer**

**Applied:** May 20-22.

**Rate:** 1 ml injection with a Wedgel (using wedge-checks) (12 percent AI)  
One injection for every 4 inches of circumference (based on trunk circumference at 1.4 m).

**Pros:**

- Trunk-injected imidacloprid presents little risk of exposure for applicators.
- Relatively low toxicity to humans, birds and some groups of non-target insects (e.g., caterpillars).
- No drift problems.
- Little impact on non-target insects or other organisms that do not feed on ash.

- Mauget: passive uptake of imidacloprid from capsules may limit injury to tree.
- Wedgel: injections can be done relatively quickly regardless of weather or tree condition.

**Cons:**

- Trunk injections of imidacloprid should occur 2 to 4 weeks before EAB are active to assure translocation through tree.
- Some minor wounding associated with injections or drilling through bark; long-term effects of annual applications on tree health are not clear.
- Rate of uptake varies, depending on soil moisture and leaf transpiration rate.
- Translocation of insecticide through the tree may be poor if trees are unhealthy or were heavily injured in previous years.

**Trunk injection – Bidrin (dicrotophos) Injecticide-B**

**Applied:** June 2 or July 14 or September 5.

**Rate:** 2 ml Mauget capsules (82 percent AI). Number of capsules injected — dbh divided by 2.

**Pros:**

- Passive uptake from capsules may limit injury to tree.
- Bidrin translocated much more rapidly through tree than imidacloprid.
- Little exposure for applicators or residents.
- No drift problems.
- Little impact on non-target insects or other organisms that do not feed on ash.

**Cons:**

- Bidrin is highly toxic to humans, birds and other organisms.
- Applicator must remain with injected tree until capsules are removed.
- Rate of uptake varies, depending on soil moisture and leaf transpiration rate.

## Evaluation of Insecticides to Control Emerald Ash Borer Adults and Larvae

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- Some minor wounding associated with injections or drilling through bark, but long-term effects of annual applications on tree health are not clear.
- Translocation of insecticide through the tree may be poor if trees are unhealthy or were heavily injured in previous years.
- May not persist as long as imidacloprid.
- Application near open water may be prohibited.
- Thorough coverage of large trees can be difficult.
- Products will be toxic to beneficial and non-target insects that contact or feed on treated leaves or bark.

### Bark and foliage cover sprays

Half of our study trees were sprayed once on May 30; the other trees were sprayed on May 30 and again on July 2. Trees were sprayed until bark and foliage were wet.  
(See Table 2).

#### Pros:

- Relatively quick to apply if weather conditions are appropriate.
- No wounds or injury to tree.
- Insecticide is effective immediately — no translocation necessary.
- May be most effective means to protect low vigor or previously injured trees in which translocation of injected insecticides is likely to be poor.

#### Cons:

- Foliage and trunk sprays will have no effect on larvae that are already under the bark.
- Drift, applicator and homeowner exposure and related issues can be a concern.

## Preliminary Results

### EAB Phenology in 2003

Adult EAB beetles were first observed on June 4-6.

Peak adult beetle activity occurred during the last week of June and first week of July.

Last observation of a live EAB adult was on August 15.

Larval galleries were first observed in late July.

### Imidacloprid Concentrations — ELISA Analysis

ELISA analysis was used to measure relative levels of imidacloprid in xylem sap from shoots collected at 2- to 3- week intervals from the canopy of ash trees at Kensington Golf Course. Trees treated with high pressure soil or trunk injections had similar levels of imidacloprid in the canopy by early June. On June 3, imidacloprid concentrations averaged 47 ppb for trees treated by high-pressure soil injected Merit, 43 ppb for trees treated with Imicide and 33 ppb for trees treated with Pointer.

**Table 2.** Chemical specs for bark and foliage cover sprays.

Chemical/formulation	Common name	Concentration in finished spray
Tempo 20WP	(cyfluthrin)	10.8 g AI/100 gal
Onyx of Biflex (2 lb AI/gal)	(bifenthrin)	0.5 lb AI/100 gal
Sevin SL (4 lb AI/gal)	(carbamate)	8 lbs AI/100 gal (bark beetle rate)
Orthene 97 (wetable granule)	(acephate)	1 lb AI/100 gal

Imidacloprid concentrations peaked on June 12 for Imicide trees (55 ppb) and on June 24 for trees treated with high-pressure soil-injected Merit (69 ppb) and Pointer (37 ppb).

Imidacloprid concentration in xylem sap dropped substantially from mid-June to late July when larval feeding began. By July 31, imidacloprid concentration averaged 4 ppb, 8 ppb and 14 ppb in trees treated with Pointer, Imicide and soil-injected Merit, respectively. This may, however, reflect translocation of imidacloprid out of xylem sap and into phloem or other tissues. Results of additional GC/HPLC analysis that are underway at the Agricultural Research Service laboratory may help to address this issue.

#### **Adult Control — Bioassays**

Bidrin (Injecticide-B) was highly effective for adult EAB control for more than 4 weeks after injection. For example, in the June 25 bioassay (23 days postinjection), 100 percent of the beetles that consumed foliage from bidrin-treated trees had died after 5 days. Relatively high human toxicity and concerns about potential impacts on non-target organisms, however, may limit the widespread use of bidrin.

Imidacloprid was not highly toxic to adult beetles. By day 5 of the June 25 bioassay (when imidacloprid concentrations were at peak levels), only 17 to 23 percent of beetles that were caged on foliage from trees treated with Pointer, Imicide or soil injected Merit had died. Imidacloprid did, however, reduce beetle feeding, and beetle mortality on treated trees was higher than control trees by day 8. In the field, we do not yet know whether adult beetles that feed on trees treated with imidacloprid generally die or recover and continue to lay eggs. Beetles that ingest a sublethal dose might also be repelled from treated trees and more likely to oviposit on untreated trees.

The concentrations of bidrin and imidacloprid needed to control EAB adults (and larvae) are not yet known.

Bark and foliage sprays effectively controlled adults for at least 2 to 3 weeks. Two applications will likely be needed to protect trees during the adult flight period that runs from early June through early to mid-August. Thorough coverage will be important.

#### **Larval Control (see Tables 3 and 4)**

High-pressure soil injections of Merit provided 88 percent control of EAB larvae in small trees at the AA-West site and 86 percent control in medium to large trees at the Kensington Golf Course site but provided no control at the Huron Hills Golf Course. The Huron Hills site included some of the largest trees in our study, and EAB density was relatively high in this area (49.8 larvae/m<sup>2</sup> in control trees). Imidacloprid levels in these trees may have simply been too low to affect ovipositing adults or larvae. The Kioritz injector provided good control in the small trees at AA-West (92 percent) but poor control in the larger trees at Kensington Golf Course (33 percent).

Imicide (trunk injection with Mauget capsules) reduced EAB density by roughly 60 to 96 percent in all sites. The highest control (96 percent) occurred at the Law/Lands site where EAB density was relatively low (16.3 larvae/ m<sup>2</sup>).

Control in trees treated with Pointer (trunk-injection with Wedgel) ranged from roughly 6 to 60 percent. Control was poorest in the large trees at Huron Hills (6 percent) and relatively low at the Law/Lands site (39 percent).

Injections of bidrin in early June produced variable results. Larval density was reduced by only 53 percent at the Lans/Lawton site but bidrin provided good control at the Kensington site (80 percent). Injections in mid-July and early

## Evaluation of Insecticides to Control Emerald Ash Borer Adults and Larvae

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September provided 82 and 77 percent control, respectively.

Two applications of Tempo, Onyx and Sevin provided consistently high levels of control (82 to 97 percent) regardless of tree size or EAB population density. Even a single application of Onyx (a new product similar to Talstar) provided good control at the two sites where it was tested. These insecticides may affect both ovipositing adults and newly hatched larvae that must chew through treated bark to reach the cambium and phloem tissue.

Evaluation of relationships between canopy dieback and effectiveness of imidacloprid is in progress.

Trees at two sites that were treated with imidacloprid were reserved for evaluation of 2-year control. Exit holes, dieback and other external symptoms will be quantified. Bark will not be removed until autumn 2004.

### Factors to Consider When Selecting a Control Strategy

**1. What is the EAB population density in your area?** The level of efficacy needed to protect trees depends on how many eggs are laid on the tree and how many larvae feed on the tree. For example, if there are only a few beetles in an area (e.g., near the edge or ahead of the core infestation), a 60 percent reduction in the density of EAB larvae is likely to provide adequate protection. On the other hand, population densities of EAB are very high in many areas of southeastern Michigan. In these areas, a 60 percent reduction in the density of EAB larvae may not be enough to protect a tree from serious injury.

- 2. How healthy and vigorous is the tree you need to protect?** Insecticides injected into the soil or trunks of trees that have sustained heavy EAB infestation in previous years will probably not be translocated effectively within the tree. For these trees, a cover spray may be a more effective means of protecting the tree from additional attacks.
- 3. What are your objectives?** Regulatory officials attempting to eradicate EAB from an area may need control strategies that provide virtually 100 percent control. However, ash trees are quite resilient and are often able to overcome minor injury caused by EAB larvae. Long-term protection of valuable shade trees may require relatively good control but not 100 percent control.
- 4. What resources are available?** Factors such as weather, other job demands and availability of labor can affect selection of control methods. Timing of soil injections, trunk injections and cover sprays and the costs associated with each product vary considerably. Some control strategies may be easier than others to integrate with other professional activities.

### Continuing Work

We expect to continue research on insecticides for EAB control, as well as other EAB-related projects related to EAB biology, host range, host resistance and dispersal. Scientists from the USDA APHIS and other universities and agencies also have EAB research underway. New research results will continue to be provided as they become available. Check the multi-agency EAB web site at [www.emeraldashborer.info](http://www.emeraldashborer.info) periodically for up-to-date information.

## Preliminary Data

**Table 3.** Mean ( $\pm$  SE) number of EAB larvae per m<sup>2</sup> in samples taken on the trunk and branches of control (untreated) trees and trees treated with an insecticide at each site. The standard error of the mean (SE) is a measure of variability within the treatment and the sample size. It is shown below the average value in each cell. A low standard error indicates that EAB density was similar on the trees in the specific treatment.

Study site	Trunk injections					Soil injections					Bark and foliage cover sprays <sup>1</sup>					
	Imidacloprid		Injecticide-B			Imidacloprid		Tempo			Onyx		Sevin		Orthene	
	Control	Imicide	Pointer	June	July	Sept	Hi Pres	Kloritz	1x	2x	1x	2x	1x	2x	1x	2x
AA-East	37.3 $\pm$ 9.55	11.2 $\pm$ 3.56							28.3 $\pm$ 15.3	0.9 $\pm$ 0.9	6.1 $\pm$ 4.36	3.0 $\pm$ 0.9	9.9 $\pm$ 5.6	2.1 $\pm$ 1.5	26.5 $\pm$ 13.0	7.1 $\pm$ 4.8
AA-West	12.7 $\pm$ 6.88	5.1 $\pm$ 1.47					1.5 $\pm$ 1.04	1.1 $\pm$ 0.75								
Huron Hills	49.8 $\pm$ 13.2	20.2 $\pm$ 11.9	46.6 $\pm$ 23.3				55.3 $\pm$ 13.7		61.2 $\pm$ 24.6	9.0 $\pm$ 5.5			49.5 $\pm$ 12.2	2.0 $\pm$ 1.4		
Law/Lands	16.3 $\pm$ 5.42	0.7 $\pm$ 0.32	9.9 $\pm$ 5.70	7.6 $\pm$ 1.72	4.4 $\pm$ 3.68											
Kens GC	42.9 $\pm$ 13.2	9.7 $\pm$ 3.71	17.5 $\pm$ 3.51	8.8 $\pm$ 3.65	7.6 $\pm$ 3.24	10.0 $\pm$ 6.64	6.2 $\pm$ 4.58	28.6 $\pm$ 8.26	19.2 $\pm$ 17.5	5.2 $\pm$ 1.2	7.0 $\pm$ 2.4	5.7 $\pm$ 4.3	13.3 $\pm$ 6.4	2.1 $\pm$ 1.7	29.9 $\pm$ 17.8	18.3 $\pm$ 7.5

**Table 4.** Average percent control of EAB larvae by treatment. Percent control is based on the number of EAB larvae per m<sup>2</sup> in treated trees compared with control trees at each site. For example, 59.8 at AA-West means that there were 59.8 percent fewer larvae in the trees treated with Imicide than in the control trees at the AA-West site. Relatively high values indicate good control.

Study site	Trunk injections					Soil injections					Bark and foliage cover sprays <sup>1</sup>					
	Imidacloprid		Injecticide-B			Imidacloprid		Tempo			Onyx		Sevin		Orthene	
	Imicide	Pointer	June	July	Sept.	Hi Pres	Kloritz	1x	2x	1x	2x	1x	2x	1x	2x	
AA-East	70.0								24.1	97.5	83.5	92.0	73.4	94.3	28.8	81.0
AA-West	59.8					88.4	91.6									
Huron Hills	59.4	6.5				0			0	81.9			0	96.0		
Law/Lands	95.7	39.3	53.4	73.2												
Kens GC	77.0	59.2	79.6	82.3	76.8	85.6	33.3		55.2	87.8	83.6	86.7	69.2	95.1	30.3	57.3

<sup>1</sup>Half the trees were sprayed only on May 30 (1x); the other trees were sprayed on May 30 and again on July 2 (2x).

## Evaluation of Insecticides to Control Emerald Ash Borer Adults and Larvae

<b>Products to Use for Protecting Ash Trees From Attack by Emerald Ash Borer</b>				
<b>For Landscapers and Arborists:</b>				
<b>Active ingredient</b>	<b>Product name</b>	<b>Timing</b>	<b>Type of Application</b>	<b>Comments</b>
Imidacloprid	Imicide	Late May	Trunk injection	Trunk injections will not work well if vascular tissue is already seriously injured.
Imidacloprid	Pointer	Late May	Trunk injection	
Bidrin	Injectacide-B	Late May to early September	Trunk injection	
Imidacloprid	Merit	Mid to late April	High pressure soil injection	
Cyfluthrin		Early June and again in early July	Trunk and foliage spray	
Bifenthrin	Onyx	Early June and again in early July	Trunk spray	
Carbaryl	Sevin	Early June and again in early July	Trunk and foliage spray	Use the bark beetle rate.
<b>For Homeowners:</b>				
Imidacloprid	Bayer Tree and Shrub Insect Control	Mid to late April	Soil drench	Mix in bucket and drench. See label directions
Cyfluthrin	Bayer Multi-Insect Killer	Early June and again in early July	Trunk and foliage spray	Trunk and foliage must be well-covered.

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