Evaluation of Insecticides for Control of Emerald Ash Borer: Summary of 2004 Trials

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Introduction

In 2003, we evaluated several insecticide products and application methods to assess their effectiveness in controlling emerald ash borer (EAB). The products included in our studies are widely available and were tested at labeled rates. Our tests included two methods (Kioritz and high volume, high pressure) of soil-injected imidacloprid (Merit 75 WP), two trunk-injected imidacloprid products (Imicide applied with Mauget capsules; Pointer applied with a Wedgle), trunk injections of bidrin (Injecticide-B [dicrotophos] applied with Mauget capsules), and cover sprays of acephate (Orthene), carbaryl (Sevin), and two pyrethroids Tempo (cyfluthrin) and Onyx (bifenthrin). These studies were conducted at five different sites and involved more than 230 ash trees.

Our results showed that the effectiveness of the insecticides and application methods varied, depending on factors such as tree size and vigor, the extent of previous EAB damage and site conditions. A summary of the results from our 2003 studies is available at http://emeraldashborer.info/treatment.cfm. We also reviewed the general pros and cons associated with each product or application method in the 2003 report.

In 2004, we conducted two studies to further evaluate the use of trunk-injected imidacloprid and bidrin for EAB control. A third study focused on the effectiveness of Tempo, applied as a cover spray. This document summarizes the objectives, methods and principal results for each of the three 2004 projects.

Project I: Trunk-injected imidacloprid; effects of timing, tree size and application methods on persistence and EAB control.
Project II: Evaluation of trunk-injected ash trees treated in 2003 and again in 2004.
Project III: Comparison of bark, foliage and whole tree sprays applied once versus twice during the summer.

Additional research on insecticides that was conducted by other scientists is summarized at:
Smitley et al. 2004. Emerald ash borer insecticide treatment information for tree care professionals. www.emeraldashborer.info.

Project I. Trunk Injections of Imidacloprid: Effects of Timing, Tree Size and Application Methods on Persistence and EAB Control

Trunk injection of products containing the active ingredient imidacloprid continues to be widely used to protect ornamental ash trees from EAB. There is surprisingly little known, however, about how long imidacloprid persists in the foliage of ash trees – in other words, will imidacloprid remain toxic to EAB adults feeding on leaves throughout the summer? We also wanted to monitor imidacloprid levels over time in phloem/xylem tissue, where it might affect EAB larvae. In addition, we needed to identify the best time to inject trees – is it better to inject trees in spring to control adult beetles, or in summer so that imidacloprid is at high levels when young larvae begin feeding? Finally, we evaluated three trunk injection methods, two imidacloprid products, and compared a high volume/low pressure trunk injection with a low volume/high pressure trunk injection.

Objectives

1. Monitor imidacloprid residues over time in xylem sap, foliage and phloem/xylem samples of all trees.

2. Quantify adult EAB mortality over time using bioassays with leaves from treated trees and untreated control trees.

3. Assess imidacloprid residues, adult EAB mortality and larval density in trees treated with a standard injection of Imicide delivered through Mauget capsules, a high volume, low pressure injection of Ima-jet using Arborjet methodology, and a low volume, high pressure Ima-jet injection using Arborjet equipment.

4. Compare imidacloprid residues, adult mortality and EAB larval density on trees injected in May (EARLY) with trees injected in July (LATE). The May injection targeted adult beetles; the July injection targeted young larvae.

5. Compare imidacloprid residues, adult mortality and EAB larval density between LARGE trees and SMALL trees.

Products and Application Methods

IMI = Imicide (10% imidacloprid) applied with Mauget capsules (low pressure, low volume) (One 3 ml capsule per 2 inches DBH[1]; 0.06g AI/cm DBH)

AJ-IV = Ima-jet (5% imidacloprid) applied with Arborjet Tree IV (low pressure, high volume, micro-infusion) (1 injection port per 2 inches DBH; 0.08 g AI/cm for SMALL trees and 0.16 g AI/cm for LARGE trees)

AJ-Inj = Ima-jet (5% imidacloprid) applied with Arborjet microinjection gun (high pressure, low volume) (1 injection port per 2 inches DBH; 0.08 g AI/cm for SMALL trees and 0.16 g AI/cm for LARGE trees)

Control = Untreated trees

[1]DBH Refers to diameter at breast height of a tree, a measurement taken roughly 1.3 m aboveground.

Study Sites

Site 1. Street trees and neighborhood trees in Ann Arbor, SMALL trees (these trees averaged 8 inch DBH with 21% dieback in May) (n = eight trees per treatment; 64 trees total)
Site 2. Neighborhood trees in Ann Arbor, LARGE trees (these trees averaged 20 inch DBH with 27% dieback in May) (n = eight trees per treatment; 64 trees total)

Dates of Treatment

EARLY injections = May 24
LATE injections = July 19

What we did

Imidacloprid residues: The EARLY trees were injected in late May, so that imidacloprid levels in foliage would be relatively high in June and July while adult beetles were feeding. If high levels of imidacloprid persisted through August, the treatment would also control young larvae. In contrast, the July injections had little effect on adult beetles but were designed to result in high imidacloprid levels in August, when larvae began feeding.

Samples of xylem sap and foliage were collected from the canopy of each tree at two-week intervals after injection from mid-June through mid-September. We also collected small plugs of phloem/xylem tissue from the trunk of each tree during each sample interval. Samples were analyzed at the USDA APHIS laboratory in Massachusetts by Phil Lewis and John Molongowski using ELISA methods. Analysis of foliage and phloem/xylem samples is still in progress but preliminary results for xylem sap samples are included here.

Adult bioassays: Leaves were collected from each treated and Control tree at two-week intervals and a leaf was placed in a Petri dish with four adult beetles. Beetle mortality was determined after six days.

Larval density: In late fall, bark was removed from at least 10 sample areas (each 400 cm^2 or larger) at regular intervals from the trunk to the upper canopy of each tree. Density of EAB larvae in each "window" was recorded and an average density for the tree was calculated.

What we found

- Residues of imidacloprid in xylem sap were significantly[1] higher in trees injected with the two Arborjet treatments (AJ-IV and AJ-Inj) than in trees injected with Mauget capsules on six of the eight sampling dates. This was not surprising because both Arborjet treatments involve injecting a greater amount of the active ingredient (imidacloprid) at each port.

- Arborjet also uses twice as much imidacloprid in large trees as in small trees to increase the likelihood that the entire canopy will be protected. We found, however, that residue levels in SMALL trees were similar to or sometimes higher than levels in LARGE trees.

- On average, residue levels in the xylem sap of the EARLY trees (treated in May) remained at 30 to 50% of the peak concentration through July.

- The LATE trees usually had higher residue levels than EARLY trees in August, when young larvae were feeding, but differences were not always significant in all sample periods.

- Beetles were more likely to die during the six-day bioassay period when they were caged with a leaf from a tree with high levels of imidacloprid residues. Mortality was consistently higher when beetles were caged with leaves from trees injected with AJ-IV or AJ-Inj compared with IMI and CONT trees, but the differences were not statistically significant in all sampling periods.

- Imidacloprid is known to trigger an anti-feedant response in many insects and that was observed in our study as well. Surviving beetles caged with leaves from treated trees consistently consumed less foliage than beetles caged with Control leaves. The anti-feedant effect likely reduces adult survival and/or the number of eggs that females can lay. Other projects are underway to address the effects of the anti-feedant response more thoroughly.

- Treated trees had significantly lower densities of EAB larvae compared with Control trees, regardless of timing or injection method.

[1]When we observe differences in a variable between treatments (e.g. larval density on trees treated with product A versus trees treated with product B), we use statistical tests to estimate the probability that the difference could have occurred by chance alone. If that probability is less than or equal to 5%, then we have confidence that there is truly a difference between the treatments. In that case, the difference is *significant*.

- EARLY injections were consistently more effective than LATE injections. Differences were most pronounced on the SMALL trees.

- On the LARGE trees with the EARLY injections, larval density did not differ significantly among the three treatments, despite higher imidacloprid residues in the AJ-IV and AJ-Inj trees. Compared with Control trees, the IMI trees had 78% fewer larvae, AJ-IV trees had 88% fewer larvae and AJ-Inj trees had 87 % fewer larvae.

- On the LARGE trees with LATE injections, larval density was 64% lower on the IMI trees, 80% lower on the AJ-IV trees, and 78% lower on the AJ-Inj trees compared with Controls. Differences among the three injection treatments were not significant.

- On the SMALL trees with EARLY injections, the IMI trees had 44% fewer larvae, the AJ-IV trees had 88% fewer larvae and AJ-Inj trees had 85% fewer larvae than Controls. Larval density was significantly lower on the AJ-IV and AJ-Inj trees than on the IMI trees.

- On the SMALL trees with LATE injections, the IMI trees had 48% fewer larvae, AJ-IV trees had 66% fewer larvae and AJ-Inj trees had 50% fewer larvae than the Control trees. Differences among treatments were not significant.

Summary: Injecting trees in late May helps to control adult beetles as well as larvae and appears to be more effective than mid-summer injections. Imidacloprid levels in xylem sap in trees treated with AJ-IV and AJ-Inj were consistently higher than levels in IMI trees, although differences were not always significant during the summer. Higher residue levels can be at least partially explained by the greater amount of imidacloprid introduced into the AJ-IV and AJ-Inj trees. High imidacloprid residue levels were generally associated with relatively high levels of adult mortality. We also consistently observed anti-feedant responses when EAB beetles were exposed to leaves with lower residue levels. This anti-feedant response may negatively affect survival or fecundity of EAB females, but additional research is needed to understand how this affects EAB reproduction.

The EARLY AJ-IV and AJ-Inj injections were more effective in reducing EAB larval density than the EARLY IMI injections on SMALL trees, but differences among treatments were not substantial on the SMALL trees injected in July. In contrast, differences among the three treatments were not significant for the LARGE trees at any either time period, despite the greater levels of imidacloprid present in the AJ-IV and AJ-Inj trees compared with the IMI trees. There may be a threshold level of imidacloprid needed to achieve effective control of EAB and increasing concentrations of imidacloprid beyond this threshold may have decreasing influence on efficacy. Further studies with small and large trees will be needed, however, to confirm this hypothesis. While none of the treatments resulted in 100% control of EAB, ash trees are relatively resilient and can tolerate minor damage from EAB or other pests.

Table 1. Average (± SE) density of emerald ash borer larvae and percent mortality of adult beetles averaged across all bioassasys. Imidacloprid residues in xylem sap represent average values for June (June 8, June 21) and August (August 4, August 17) for each treatment.

Site	Treatment	Timing	Larvae (per m^2)	% Adult mortality	Residues (ppb) Jun 8 & 21	Residues (ppb) Aug 4 & 17
1. Large Trees	Control	**Early**	60.3 ± 17.4	23.2 ± 3.4	---	---
	Mauget/Imicide		13.4 ± 4.5	44.3 ± 5.0	34.3 ± 15.8	22.6 ± 9.9
	Arborjet Inj		7.9 ± 2.8	63.5 ± 9.0	43.9 ± 15.3	124.7 ± 40.7
	Arborjet IV		6.9 ± 3.3	69.3 ± 6.9	167.2 ± 41.9	89.0 ± 22.9
	Control	**Late**	60.3 ± 17.4			---
	Mauget/Imicide		21.8 ± 6.4			39.9 ± 26.5
	Arborjet Inj		13.3 ± 3.9			113.4 ± 42.7
	Arborjet IV		12.0 ± 5.7			183.1 ± 47.3
2. Small Trees	Control	**Early**	134.0 ± 15.7	38.5 ± 6.6	---	---
	Mauget/Imicide		75.1 ± 13.2	45.8 ± 6.6	57.5 ± 45.6	34.7 ± 16.5
	Arborjet Inj		20.0 ± 6.4	85.4 ± 4.8	487.2 ± 190.0	88.9 ± 26.8
	Arborjet IV		15.6 ± 4.8	85.9 ± 5.7	231.9 ± 86.6	116.1 ± 34.9
	Control	**Late**	134.0 ± 15.7			---
	Mauget/Imicide		69.9 ± 15.3			77.4 ± 41.9
	Arborjet Inj		66.8 ± 14.6			161.3 ± 84.4
	Arborjet IV		45.1 ± 12.9			284.7 ± 92.6

Project II. Long-term Survival of Trunk-Injected Trees

We injected trees with commonly used insecticide products in 2003 and again in 2004. We hope to continue annual trunk injections to monitor the EAB densities in treated and untreated control trees over time. At one site, green and white ash trees of similar age and size were included in the tests. This should allow us to compare EAB attack densities between untreated green and white ash and to determine if treatment efficacy varies between the two species.

Objectives

1. Monitor canopy condition and EAB density over time in trees treated annually with a trunk injection of imidacloprid or bidrin.

2. Compare differences in EAB density or insecticide effectiveness between green ash and white ash trees treated annually with imidacloprid.

Products & Application Methods

Imidacloprid
Imicide (10% AI) applied with Mauget capsules (One 3 ml capsule per two inches DBH[1])
Applied May 20, 2003 and May 24, 2004

Pointer (12% AI in 2003; 5% AI in 2004) applied with a Wedgle (one injection per four inches basal circumference)
Applied May 20, 2003 and May 19, 2004

Bidrin (dicrotophos)
Injecticide-B (82% AI) applied with Mauget capsules (One 2 ml capsule per two-inches DBH).
Applied June 2 (EARLY) or June 14 (LATE), 2003,
Applied June 15 (EARLY) or July 16 (LATE), 2004

Control – untreated trees

Study Sites

Both sites involve street trees in Ann Arbor neighborhoods. Trees had no more than 10% canopy dieback at the beginning of the study in June 2003.

Site A
Green ash and White ash trees (n = six of each species per treatment)
Average DBH = 6 inches
Treatments: Imicide, Pointer, Control

Site B
Green ash trees (n = six trees per treatment)
Average DBH = 16.5 inches
Treatments: Imicide, Pointer, Bidrin (Early), Bidrin (Late), Control

What we did

In September 2004, we estimated the density of EAB larvae that developed in 2003 (following the first insecticide application) by recording the number of exit holes left by emerging beetles in 2004. Exit holes were counted on six sample areas located on the trunk and branches of each tree. We also estimated the density of EAB larvae that were feeding in 2004 in three "bark windows" in the canopy of each tree. Canopy condition of each tree was visually estimated in early June 2003 and September 2004.

What we found

Site A – Green Ash.

- Density of EAB in Control green ash trees increased by more than two-fold from 2003 to 2004 (Table 1).

- Green ash trees treated with either insecticide (Imicide or Pointer) had significantly lower densities of EAB than the Control trees. Ash borers that developed in 2003 and emerged in 2004 were 94% lower in the Imicide trees and 74% lower in the Pointer trees than in the untreated Control trees.

- The density of larvae feeding in 2004 was 88% lower in the Imicide trees and 45% lower in the Pointer trees.

- Canopy condition of the Control trees declined at a much greater rate than the treated trees. Average canopy dieback for Control trees increased from roughly 12% dieback in 2003 to 63% dieback in 2004. From 2003 to 2004, canopy dieback for Imicide trees increased from 5% to 26% and from 6% to 35% for Pointer trees.

Site A – White Ash.

- Our data show that EAB demonstrate a strong preference for green ash and are much less likely to colonize white ash. In 2003 in Control white ash trees, there were less than 2 EAB per m^2 on average, compared with almost 36 EAB per m^2 in the neighboring green ash trees. Density of EAB in the Control white ash trees increased to 19.4 EAB/m^2 from 2003 to 2004.

- In 2003, EAB density was very low in the treated trees, averaging 1.5 and 1.8 larvae per m^2 in the Imicide and Pointer trees, respectively.

- Densities increased in 2004, although they were still quite low compared with green ash trees. On average, there were 6.3 and 11.1 larvae per m^2 in the Imicide and Pointer trees, respectively.

- Canopy condition of white ash trees did not decline substantially from 2003 to 2004. Canopy dieback was less than 10% on Control trees on average, about 13% on Imicide trees and 17% on Pointer trees.

Site B – Green Ash

- Density of EAB in 2003 was quite low for all trees regardless of treatment (Table 1).

- In the Control trees, density of EAB increased dramatically from 2003 to 2004, with an average of 78 EAB larvae per m^2 in 2004.

- Density of EAB was 96% lower in Imicide trees and 82% lower in the Pointer trees than the Control trees in 2004.

- Trees treated with an Early injection of Injecticide-B had 82% fewer EAB/m^2 than Control trees.

- The late injection of Injecticide-B was similarly effective – EAB density was 84% lower than in Control trees.

- Canopy condition declined on all trees from 2003 to 2004, but dieback was most severe on the Control trees, where trees averaged 20% dieback in 2003 compared with 51% dieback in 2004. Dieback ranged from roughly 14 to 18% on treated trees in 2003 and from 25 to 30% in 2004, with little difference among insecticide treatments.

Summary: All three insecticides reduced the density of EAB compared with Control trees. The differences between treated and Control trees were statistically significant for the green ash trees in both sites, but not for the white ash in Site A where overall EAB densities were lower. Differences among the insecticide products were not significantly different.

The canopy condition of the green ash Control trees declined markedly at both sites from 2003 to 2004. The amount of dieback on the green ash trees that had been treated with an insecticide also increased from 2003 to 2004 but, on average, the treated green ash trees had 30-35% dieback or less in 2004. Canopy condition of white ash trees at Site A did not decline substantially, presumably because of the low density of EAB on these trees in both 2003 and 2004.

Our data from this study, and other ongoing studies, consistently show that EAB prefers to attack green ash even when similarly sized white ash are growing in the same area. This may reflect differences in the chemicals associated with the two species and/or differences in physical characteristics of the trees. For example, young green ash often have rougher bark than young white ash and EAB females seem to prefer laying eggs on trees with rough bark. As the green ash trees begin to seriously decline and die, we expect to see increased densities of EAB on the white ash trees.

Table 2. Average percentage of the canopy that was dead and estimated density of EAB in 2003 and 2004 in ash trees at two sites.

	Treatment	**Species**	**Canopy Dieback (%)**		**EAB per m^2**	
Site A			**2003**	**2004**	**2003**	**2004**
	Control	White	3.7 ± 3.7	8.0 ± 4.9	1.4 ± 0.5	19.4 ± 19.4
	Mauget/Imicide		0.7 ± 0.7	12.6 ± 4.9	1.6 ± 0.6	6.3 ± 4.1
	Wedgle/Pointer		4.0 ± 2.4	17.2 ± 6.1	1.8 ± 1.1	11.1 ± 3.5
	Control	Green	11.7 ± 4.0	63.4 ± 10.5	35.8 ± 12.7	80.6 ± 10.0
	Mauget/Imicide		5.0 ± 3.2	25.8 ± 7.1	2.3 ± 1.6	9.3 ± 7.3
	Wedgle/Pointer		5.7 ± 3.0	35.4 ± 8.1	9.3 ± 1.8	44.4 ± 13.7
Site B	Control	Green	20.0 ± 11.5	51.0 ± 10.6	8.1 ± 2.9	78.2 ± 23.8
	Mauget/Imicide		18.0 ± 3.8	29.7 ± 12.3	2.2 ± 1.8	2.8 ± 2.8
	Wedgle/Pointer		18.0 ± 3.6	30.3 ± 3.8	0.9 ± 0.6	14.4 ± 7.1
	Mauget/Bidrin E		13.8 ± 2.6	25.3 ± 6.3	3.0 ± 1.3	12.5 ± 2.8
	Mauget/Bidrin L		17.7 ± 8.9	28.5 ± 8.9	0.4 ± 0.3	8.3 ± 4.3

Project III. Cover Sprays: Trunk versus Canopy and 1 versus 2 sprays

Cover sprays may be useful in some situations, especially where trunk or soil injections are not appropriate. In 2003, we found that spraying trees in June and again in July with Tempo (cyfluthrin), a pyrethroid insecticide, provided highly effective control of EAB. In 2004, we evaluated the control provided by a single spray versus the control provided by two applications. In addition, we compared the effectiveness of spraying the entire tree with spraying only the foliage or only the trunk. When entire trees are sprayed, EAB control may result from mortality of (1) adult beetles when they feed on leaves or lay eggs on branches in the canopy, (2) adult females when they lay eggs on the trunk or (3) tiny larvae when they hatch from eggs and chew through the bark to the phloem. Our study was designed to assess whether we could get good control by spraying only the trunk, thereby reducing the amount of insecticide in the environment and potential exposure. We also sprayed only the canopy of some trees, while other trees were thoroughly covered. This design helped us to determine whether newly hatched larvae are strongly affected by the insecticide or whether control is mostly a result of adult beetle mortality.

Objectives

1. Assess mortality of EAB adults, four and eight weeks after trees are sprayed, to evaluate persistence of Tempo.

2. Compare density of EAB larvae in fall among Control trees, trees sprayed once, trees sprayed twice, trees that received two trunk sprays and trees that received two canopy sprays.

Products and Application Methods

Tempo SC Ultra (cyfluthrin) was applied at a rate of 160 ml per 378 l (100 gal). Trees were sprayed to run off by an experienced, commercial applicator. (n= eight trees per treatment, 40 trees total).

WT-2X = Whole tree sprayed on June 10 and again on July 2
WT-1X = Whole tree sprayed on June 10 only.
CAN = Canopy only sprayed, June 10and July 2. The trunk and lower branches were wrapped with plastic during spraying to protect the trunk from the spray.
TRUNK = Trunk only sprayed on June 10 and July 2.
Control = Untreated trees were not sprayed.

Study Site

We used street trees in Ann Arbor for this project. Trees had an average DBH of roughly 8 inches and 21% canopy dieback in early June 2004.

What we did

- We collected leaves from the canopy and small sections of bark from each treated and Control tree four weeks and eight weeks after the June 10 spray was applied. Four adult beetles were caged with each sample in a Petri dish. For the bark samples, beetles were provided with an untreated ash leaf. Beetle mortality was determined after five days of exposure.

- Larval density was determined in fall by counting EAB larvae in eight bark windows (each roughly 400 cm^2) spaced at regular intervals from the base to the upper canopy of each tree. Four windows were on the trunk and four windows were in the canopy. Density of larvae was compared among treatments and between larvae feeding on the trunk versus larvae feeding in the canopy.

- Results from other studies indicated that some EAB larvae require two years of feeding to complete development. Therefore, we reexamined WT-2X and Control trees to estimate the proportion of one-year larvae (hatched and completed feeding in 2004) with the proportion of two-year larvae (hatched in 2003 but fed in 2003 and 2004).

What we found

- Average mortality of beetles caged with unsprayed foliage from TRUNK trees, unsprayed bark from CAN trees and samples from Control trees was less than 20%.

- In comparison, more than 90% of adult beetles died when they were caged with a sprayed leaf or a sample of sprayed bark on WT-2X, CAN and TRUNK trees.

- Eight weeks after spraying, beetle mortality on WT-1X trees averaged 90% and 71% on samples from TRUNK and CAN trees, respectively. This suggests that Tempo may persist slightly longer on the bark than on leaves in the canopy, where exposure to rain and UV light is greater.

- On Control trees, 60 to 70% of ***large*** larvae (4^{th} instars) were two-year larvae and 90% of the ***large*** larvae on WT-2X trees were two-year larvae. Two-year larvae that were already under the bark when sprays were applied would not have been affected by the insecticide. There was no significant difference in the density of two-year larvae between Control and WT-2X trees.

- The ***large, one-year*** larvae that began feeding in 2004 (after trees were sprayed) were 85% lower in the WT-2X trees than in the Control trees.

- Additional sampling is underway to estimate the proportion of one-year and two-year larvae in the WT-1X, CAN and TRUNK trees.

- If we evaluate counts of ***young*** EAB larvae (first, second and third instars) only and assume that these were all one-year larvae, we can estimate efficacy of the treatments. Density of young larvae feeding on tree <u>trunks</u> was reduced by 88% compared with Control trees when the foliage (CAN) or trunk and foliage (WT-2X, WT-1X) were sprayed. Density of young larvae feeding on the trunk was reduced by 40% when only the trunk (TRUNK) had been sprayed. This suggests that control is primarily achieved through mortality of adult beetles, rather than mortality of newly hatched larvae.

- Density of ***young*** larvae feeding in the <u>canopy</u> was reduced by 66 to 90% when the foliage (CAN) or trunk & foliage (WT-2X, WT-1X) were sprayed, but by only 14% when just the trunk (TRUNK) was sprayed. This pattern is consistent with the idea that it is most important to control adult beetles that feed and spend large amounts of time in the canopy. Additional sampling to determine the proportion of one-year and two-year larvae in all trees must be completed, however, before we can assess treatment differences with confidence.

- Average density of EAB larvae was somewhat higher in trees that were sprayed only once (WT-1X) than in trees sprayed twice (WT-2X) but differences were not significant. This indicates that a single, well-timed spray may be as effective as two sprays applied at 4 week intervals.

Summary: Additional sampling is needed to thoroughly assess the effectiveness of the insecticide treatments. Preliminary results suggest that a single spray applied in mid-June may provide effective control during the summer. Applying a single spray instead of two sprays would reduce applicator exposure, environmental contamination and costs. Spraying only the trunk is not likely to be effective, but spraying only the canopy may be nearly as effective as spraying the entire tree. Larvae that are already under the bark, however, will not be affected by a cover spray. More research is needed to understand what factors influence the development rate of EAB larvae and how common multi-year development is in southeastern Michigan.