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Emerald Ash Borer Control:
A Guide for Professionals

Rafia Khan[1], Molly Keck[2], Wizzie Brown[2], and Patrick Porter[3]

The products listed in this factsheet are meant to be applied by professional, licensed applicators.

The emerald ash borer (EAB), *Agrilus planipennis* Fairmaire (Fig. 1), is an invasive pest expanding its range in Texas and will eventually kill native and non-native ash trees. A companion publication (Emerald Ash Borer in Texas (ENTO-PU-225)) covers EAB host range, biology, damage symptoms, quarantine rules, and homeowner control options. That publication also explains why EAB infestations often go unrecognized for a year or more, why high-value trees need insecticidal protection before they show obvious symptoms of infestation, and how much damage makes a tree unrecoverable. Insecticides are the only option to protect ash trees from EAB infestation. The present publication specifically discusses professional chemical control of EAB with different insecticide options. Products differ by complexity of application, mode of action, efficacy, longevity of control, cost per tree, label restrictions on maximum use per acre, and other factors. The location and economic value of the infested or vulnerable trees must be considered. Tree care professionals of landscape, park, natural, or private areas often need to provide choices to their clients. This publication is intended to help encapsulate the strengths and weaknesses of different insecticide options.

Figure 1. Adult emerald ash borer (EAB). *(Photo courtesy of Randy King)*

Trees at Risk and Treatment Options

All healthy and stressed North American ash, (*Fraxinus* spp., Oleaceae plant family), white fringe trees (*Chionanthus virginicus*), and European olive (*Olea europaea*) of all sizes are susceptible to EAB infestation (Peterson et al., 2020). Currently, biological control agents for EAB are not commercially available in the United States. Woodpeckers are known as natural enemies of EAB and can indicate EAB activity, but do not provide sufficient management.

Insecticidal treatments are the only feasible option to save host trees (Herms et al., 2019; McCullough, 2019). Emerald ash borer females lay eggs on the bark of host trees. Eggs hatch into larvae (Fig. 2), building galleries below bark in the phloem and cambium layers (the cambium layers producing new wood and conductive tissues). This results in tree girdling, disrupting the transport of water and nutrients, and leading to the tree's death. Current EAB management options target EAB's two life stages: larvae and adults.

Figure 2. Larval EAB under bark on ash trees. *(Photo courtesy of Kenneth R. Law, USDA APHIS PPQ, Bugwood.org)*

Emerald ash borer females lay eggs on trees within 100 yards of their emergence,

[1]Assistant Professor and Extension Entomologist
[2]Senior Extension Program Specialist
[3]Professor and Extension Entomologist
All Texas A&M AgriLife Extension Service

although they can disperse as far as 2 to 3 miles. This movement, and the fact that it might be several years before infested trees are recognized, suggests the host trees within 30 miles of symptomatic EAB damage are at risk and should be treated prophylactically (Herms et al., 2019). Insecticidal treatment of healthy or less infested trees (less than 30 percent canopy reduction) is more cost-effective than the removal of those trees.

Conditions to Apply Insecticidal Treatments

Emerald-ash-borer-infested trees with over 30 percent canopy decline (Figure 3) cannot be recovered using insecticidal treatments. The inner bark (phloem) and cambium layer, which transport food to the upper trunk and leaves, is too damaged by larval feeding. The outer wood or xylem layer is also affected and can no longer transport water and uptake insecticides for treatments to be effective. Insecticidal treatments should be applied to the tree when it is healthy enough to transport the insecticide throughout the trunk, branches, and canopy. Applying insecticides to trees with less than 30 percent canopy decline can prevent further injury but requires repeated insecticide applications and time for full recovery. Once established in an area, EABs have never been eradicated. Thus, insecticidal treatments need to be applied to valuable trees for their lifetime. The recovery of infested trees takes time and may not be visible after the first year of insecticidal treatments. The tree canopy may improve during the second year of treatments if the insecticide is effective at reducing the larval population enough to recover the tree's vascular tissues. Larger ash trees (greater than 15 inches in diameter at breast height) should have insecticidal treatments completed by a professional. The most effective insecticides for EAB management include systemics which are transported within the tree.

Figure 3. Emerald-ash-borer-infested ash trees with more than 50 percent canopy loss. *(Photo courtesy of Daniel Herms, The Ohio State University, Bugwood.org)*

Insecticide Treatment Options, Application Methods, and Their Effectiveness in Managing EABs

Insecticidal treatments can manage both adult and larval life stages. Application of insecticides in spring is often more effective than fall treatments since young larvae are more susceptible than older larvae. Several insecticides are labeled for EABs (Table 1) and fall into four major categories according to their application method and efficacy (Herms et al., 2019).

a. ***Soil-applied systemic (drench) insecticides***
These products contain the active ingredients imidacloprid or dinotefuran, and are mixed with water and poured directly into the soil around the base of the tree. It is recommended to remove mulch, dead leaves, or ground covering before drenching. Soil-applied systemic insecticides can also be injected into the soil. Applying insecticides by injection requires specialized equipment and provides better placement of insecticides directly to the root-zone area without runoff or removal of mulch. The product solution should be injected to a depth of 2 to 4 inches below the soil surface and within 18 inches of the trunk since the insecticides are not photostable. The pest pressure and diameter at breast height (DBH) of the tree should be considered to determine the amount of insecticide to use (consult the product label for specific instructions). Depending on the product, higher rates should be applicable for larger trees with DBHs greater than 15 inches, but smaller trees require lower rates. Soil around the tree needs to be irrigated before and after drenching applications for better uptake by the roots, if the soil is dry. In Texas, treatments of soil-applied imidacloprid should start in early spring because this chemical takes 4 to 6 weeks to distribute through the canopy.

Effectiveness: Systemic insecticides applied to soil will eventually make their way through the tree and to the leaves. Soil-applied systemic insecticides (imidacloprid and dinotefuran) show variable results. Spring applications of soil drenches of imidacloprid effectively protects trees from EABs better than fall applications. Smitley et al. (2015) found that annual applications of imidacloprid at a rate of 0.8g a.i./cm DBH (a.i. = active ingredient) or higher can provide better protection than the rates of 0.56g a.i./cm DBH. Soil drench applications of dinotefuran at the highest labeled rate was more effective in protecting trees than the lower rates. Research suggests that adding clothianidin or fertilizer to imidacloprid formulations did not improve EAB protection. Trees can uptake insecticides better when applied at the base of the trunk than when applied by a grid or circular pattern through soil drenches or injection.

b. *Injectable systemic insecticides*

Trunk injection (Figure 4) of systemic insecticides is highly effective for all trees, regardless of size, including trees planted on sites where soil application of insecticide is limited (wet, sandy, compacted, or restricted soil). Application of insecticides through injection on a large-scale can be costly. Products are applied through high-pressure injections by making small holes in the bark to inject the product directly into the tree's transport system. Trunk-injected products are transported to the upper trunk and canopy more quickly than drench applications. Emamectin benzoate, azadirachtin, and dinotefuran are more soluble than imidacloprid and can reach the tree canopy faster. It's best to perform a morning application of the product in the trunk of trees on irrigated soil.

Effectiveness: In multiple comparative trials, emamectin benzoate provided superior efficacy over other systemic insecticides (Flower et al., 2012; McCullough et al., 2011). Emamectin benzoate can provide complete protection from EAB infestation for 3 years after application on trees with 5- to 21-inch DBHs. In a separate study, a single application of emamectin benzoate provided excellent control of EABs for 2 years for medium-sized trees (15- to 25-inch DBH). Plants treated with emamectin benzoate showed no canopy decline and low numbers of adult exit holes. Another study looked at application of emamectin benzoate at medium-low or medium-high rates in alternate years (three treatments). The results showed continuous healthy canopy after 6 years of initial treatment to trees with 32- to 53-inch DBH. Even trees with 28- to 62-inch DBH were found to be protected by the two applications of emamectin benzoate (once every 3 years) at a medium rate.

Figure 4. Trunk injection of insecticides on ash trees by professionals. *(Photo courtesy of David Cappaert, Bugwood.org)*

Trunk injections of imidacloprid products vary in efficacy in managing EAB in affected trees. Trees injected with imidacloprid product (IMA-jet®) annually with high percentages of active ingredients provided good control of EAB on 15- to 25-inch DBH trees under high pest pressure.

Trunk injection with azadirachtin provides less direct control than other systemic insecticides. Trees treated with azadirachtin trunk injection are not acutely toxic to EAB adults compared to emamectin benzoate or dinotefuran. However, azadirachtin was found to reduce the ability of mature female beetles to produce viable eggs, resulting in lower hatch rates. Interestingly, young adult females were observed to recover from the treatments to reproduce normally. Azadirachtin can be effective in protecting trees for 1 to 2 years, but annual application is required with higher EAB densities.

c. *Lower trunk sprays with systemic insecticides*

Dinotefuran insecticides are fast-acting due to their water-soluble properties. When the insecticide is applied on the lower 5 to 6 feet of the trunk with a sprayer, the insecticide can be quickly transported systemically throughout the tree, regardless of tree size.

Effectiveness: Current studies suggest that the effectiveness of lower trunk dinotefuran sprays is comparable to that of soil applications of either dinotefuran or higher rates of imidacloprid. Dinotefuran trunk sprays were translocated to the leaves at the same rate as emamectin benzoate, and faster than soil-applied imidacloprid. Annual applications of dinotefuran lower trunk sprays have been shown to effectively protect ash trees. These applications lead to a significant reduction in EAB larval densities when compared to untreated trees with heavy infestations. A 5-year study at Ohio State University found that annual applications of the highest labeled rate provided more effective control of EAB populations than the lower rate in ash trees with DBH up to 22 inches.

d. *Cover sprays to trunk, branches, and foliage with contact insecticides*

Cover sprays on trunk, branches, and foliage can manage adult EABs and newly hatched larvae before they bore into the bark. However, they will not affect larvae that are already present beneath the bark. Apply after the adult emergence of EABs and repeat every 3 to 4 weeks to foliage when EAB adults are active, all according to label instructions. Pyrethroid insecticides are short-lived and multiple applications are required. Foliar application is not an adequate way to successfully manage EABs. Cover sprays are recommended when most adult beetles have emerged (late spring to early summer

with the presence of new D-shaped exit holes). If you watch for the presence of new D-shaped exit holes, paint the previous or "old" exit holes with brightly colored paint to discern what holes are new.

Effectiveness: Several products of pyrethroids (e.g., OnyxPro® and Tempo® SC ULTRA) were found to be effective in managing EABs if applied during adult activity. Applying cover sprays on foliage, upper branches, or whole trees can be more effective in managing EAB adults than applying only on the trunk or larger branches. A single timely application of cover spray can provide effective control of EABs. However, a repeat application can provide additional protection over the longer active period of EAB adults.

Insecticide Table

The products listed in the below table help professionals manage EABs (Herms et al., 2019; Leisch and Williamson, 2022). They are meant to be applied by professional, licensed applicators.

Potential Side Effects of Using Insecticides

Management of EABs to protect host trees in landscape, municipal areas, parks, and recreational areas largely depends on treatment with systemic insecticides. Systemic insecticides with the active ingredients imidacloprid, dinotefuran, and emamectin benzoate are considered more effective in managing EABs and are safer for nontarget organisms than foliar or cover sprays.

Concerns about applying cover sprays include spray drift, contamination of the environment, nontarget organisms, and exposure to the applicator. Imidacloprid and dinotefuran products are known for their rapid degradation in water with the presence of sunlight compared to the in-ground application. The application of trunk-injected insecticides can reduce the chances of ground- or surface water contamination. Applying systemic insecticides on the trunk of a tree, which avoids application to porous sandy soils, can protect groundwater. Surface water can be protected by avoiding the application of

Table 1. Insecticides for EAB management.

Insecticide Class	Active Ingredients (Trade Name)	Method of Application	Recommended Timing and Use	Relative Efficacy and Frequency of Application
Pyrethroids (3A) (Contact insecticides)	Bifenthrin (OnyxPro®) Cyfluthrin (Tempo® SC ULTRA) Permethrin (Astro®)	Preventive trunk, branch, and foliage cover sprays.	Late spring to early summer. Two applications a month apart.	Moderate: can protect trees for 1 year.
Neonicotinoids (4A) (Systemic insecticides)	Imidacloprid (Merit® 75 WP, Merit® 75 WSP, Merit® 2F, Xytect® 2F)	Soil injection or drench.	Early to middle spring or middle fall.	Good: can protect trees for 1 year.
	Imidacloprid (Imicide™)	Trunk injection.	Middle to late spring after trees have leafed out.	Very good: can protect trees for 1 to 2 years.
	Dinotefuran (Safari® 20 SG, Transtect™, Zylam® Liquid Systemic Insecticide)	Soil injection, soil drench, or trunk spray.	Middle to late spring for soil application, or middle to late spring after trees have leafed out.	Very good as trunk spray: can protect trees for 1 year. Good as soil application: can protect trees for 1 year.
Avermectins (6) (Systemic insecticides)	Emamectin benzoate (ArborMectin®, TREE-äge G4, TREE-äge R10)	Trunk injection.	Middle to late spring after trees have leafed out.	Excellent: can protect trees for 1 to 3 years.
Azadirachtin (UN) (Systemic insecticides)	Azadirachtin (AzaSol™, Lalguard AZA, TreeAzin™ Systemic Insecticide)	Trunk injection.	Middle to late spring after trees have leafed out.	Very good: can protect trees for 1 to 2 years. Annual application is required with higher densities of EABs.

There may be other insecticides with the same active ingredients to use for EAB.

systemic insecticides next to water bodies and inclined surfaces. Pesticide label directions will usually be specific in how far from water bodies you should apply products.

The wounds caused during the trunk injection through drilling outer bark can be minor if injected properly. This is followed by the formation of new wood over time without any evidence of pathogen infection or decay.

Ash trees produce short-lived flowers in early spring, which are pollinated by wind and are not a nectar source for bees. Avoiding the application of systemic insecticides before flower production can limit the direct exposure to pollinators. Research has found that residues of systemic insecticides were rarely found in ash pollen. However, the activity of ground-dwelling nontarget species can be impacted by liquid or granular systemic insecticides. Check for label restrictions when applying systemic insecticides by drenching on flowering ash trees. There may be specific application instructions to conserve bees and other pollinators. These insecticides are also safe for woodpeckers because they feed on living larvae rather than those killed by insecticides.

A thorough monitoring program to evaluate the treated trees can help to decide whether to stop, extend the interval, or apply repeat or annual application of treatments (Hahn et al., 2011).

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