

EVALUATION OF NEO-NICOTINOID INSECTICIDES APPLIED AS NON-INVASIVE TRUNK SPRAYS

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ABSTRACT

Neo-nicotinoid insecticides such as imidacloprid and dinotefuron are widely used in southeastern Michigan to protect ash (*Fraxinus* sp.) shade trees from emerald ash borer (EAB), *Agrilus planipennis* Fairmaire. These products are relatively safe for humans and have few non-target effects. Trees are generally treated annually by injecting the insecticide into the soil or into the trunk. The product is translocated to the canopy, where it affects adult beetles during the summer. Questions and concerns have arisen about the long-term effects of repeated wounding associated with trunk injection, the time required to apply or monitor trunk-injected products, and possible movement of soil-injected products into soil or ground water at some sites.

We evaluated a non-invasive, efficient, and simple method of applying imidacloprid or dinotefuron to the trunk of ash shade trees. This application method involves mixing the insecticide with Pentra-Bark®, a non-toxic, bark-penetrating surfactant (Agrichem, Medina, Ohio). The formulated solution is applied directly to the bark on the lower trunk of a tree with a common garden sprayer. Pentra-Bark®, originally used as an agricultural surfactant, has recently been shown to carry fungicide products through the bark and into the xylem tissue of fruit trees, where the product is then translocated to the canopy. In our study, we sprayed the bark on the trunks of the trees until they were wet from 20 cm to 1.6 m aboveground.

The randomized complete block design was replicated at four sites to ensure that we evaluated a range of tree size and bark thickness. Mean diameter at breast height (DBH) of trees used in the study ranged from 5.0 inches at the site with the smallest trees to 15.5 inches at the site with the largest trees. There were six to 12 trees per treatment at each of the four sites. Each block consisted of trees treated with a non-invasive trunk spray of (1) imidacloprid + Pentra-Bark®, (2) dinotefuron + Pentra-Bark®, (3) a soil application of imidacloprid applied at the base of the tree with a Davey wand, (4) a trunk injection of imidacloprid applied with Mauget capsules (e.g., a positive control), or (5) left as an untreated control (Table 1). Dinotefuron treatment was not included at one site. Data were analyzed with analysis-of-

variance or the nonparametric equivalents and multiple comparison tests (when ANOVA results were significant) to assess effects of treatment and site ($P < 0.05$).

To evaluate the effectiveness of the insecticide treatments, we measured residues in leaves collected from each tree in mid-June, early July, late July, and mid-August using HPLC (for dinotefuron) or ELISA (for imidacloprid). Dinotefuron levels in foliage peaked in mid-June at all three sites. Average concentrations exceeded 2.0 ppm at two sites and levels exceeded 5.0 ppm at the site with the smallest trees. Dinotefuron residues dropped relatively quickly to roughly 1.0 ppm at two sites and 2.0 ppm at the site with the small trees by early July. Imidacloprid residues have been determined for mid-June and early July only; other samples are still being processed. Trees treated with Mauguet capsules generally had the highest imidacloprid residues; on average, residues averaged at least 5 ppm compared to average residues of 1.0 to roughly 3.0 ppm in trees treated with soil application or the trunk spray. Residue levels in Mauguet trees were similar in mid-June and early July, while residue levels in the other treated trees increased from mid-June to early July. Residue levels were substantially higher at the site with the smallest trees compared to residues in larger trees at the other sites.

Bioassays were conducted in mid-June, early July and late July to assess survival of EAB adults caged with leaves from each study tree. On each date, two leaves were collected from opposite sides of each tree, and three beetles were placed on each leaf for four days. In mid-June, EAB survival on leaves from Mauguet-treated trees was significantly lower than EAB survival on other trees on Day 1 of the bioassay. By Day 4, EAB survival on leaves from all treated trees was significantly lower than survival on the untreated control trees. In early July, survival was monitored daily. Survival of EAB on trees treated with dinotefuron + Pentra-Bark® was significantly lower than on the untreated control trees on Day 1, and survival on all treated trees was lower than survival on untreated controls on Days 2-4. In the late July bioassay, EAB survival on trees treated with dinotefuron + Pentra-Bark® was significantly lower than survival on all other trees on Day 1. By Day 4, survival on all treated trees except the Mauguet-treated trees was significantly lower than the untreated controls. We noted that 13 of the trees treated with the dinotefuron + Pentra-Bark® spray had leaf residues that exceeded 2.0 ppm; on 12 of those 13 trees, no EAB survived to Day 4.

Larva density was quantified beginning in late September and continuing into October using bark windows ($>500 \text{ cm}^2$, each) excavated on the trunk and four to six locations in the canopy. Overall EAB larva density was low at the site with the largest trees ($<10 \text{ EAB/m}^2$), and there were no significant differences among treatments. At a second site where only imidacloprid treatments were applied (no dinotefuron treatment), the EAB population was moderate. Larva density was highly variable, however, and between-treatment differences were not significant. At the third site, with a low to moderate EAB population, trees treated with dinotefuron + Pentra-Bark®, a soil application of imidacloprid, or the Mauguet capsules had significantly lower larva density than untreated controls. Trees treated with the imidacloprid + Pentra-Bark® spray did not differ significantly from other treated trees or the untreated controls. On average, trees treated with the imidacloprid + Pentra-Bark® trunk spray, the soil application of dinotefuron + Pentra-Bark®, or the Mauguet capsules had 50 percent, 71 percent, 75 percent and 81 percent fewer larvae per m^2 , respectively, than untreated controls. Density of EAB at the site with the smallest trees was very low; these trees were not debarked and will likely be used in 2007 studies.

Our results indicate that insecticides penetrated the bark and moved into the vascular tissue of trees treated with trunk sprays of imidacloprid + Pentra-Bark® and dinotefuron + Pentra-Bark®. Thus, the insecticides could effectively translocate to the canopy. Foliar imidacloprid residues on trees treated with the non-invasive trunk spray were similar to residues in trees treated with a soil application or a trunk injection using Mauget capsules. Dinotefuron, which is highly soluble in water, appeared to translocate relatively rapidly into the canopy. Residue levels were substantially lower in early July than in mid-June, however, suggesting that the product may break down relatively quickly. Foliar imidacloprid residues were highest in mid-June and early July in trees treated with the trunk injection (Mauget capsules). Residue levels in other imidacloprid trees increased from mid-June to early July, suggesting that the product may have still been moving into the canopy or foliage. In bioassays, EAB mortality was significantly higher when adults were fed leaves from trees treated with either imidacloprid or dinotefuron compared to untreated control trees. Adult mortality on Day 4 of the bioassays ranged from 34-61 percent among imidacloprid-treated trees and 62-82 percent on dinotefuron trees. Larva density was highly variable within and among trees at all sites. Generally, larva density was lower on treated than untreated trees, but differences were significant at only one site. We plan to continue to evaluate the non-invasive application methods in 2007.

Table 1. Application rates and dates for imidacloprid (Imi) and dinotefuron (Dino) treatments applied to ash trees in 2006.

Treatment	Application method	Product	AI per inch DBH	Application date
Untreated controls	—	—	—	—
Trunk injection (positive control)	Mauget capsules (3 ml)	10% imicide	0.15 g	May 29
Soil application	Davey wand at base of tree	Macho 2F (21.4%)	1.42 g	May 22
Imi + Pentra-Bark® trunk spray	Garden sprayer; 3.2 fl oz/inch DBH	Macho 2F (21.4%) + 3 oz Pentra-Bark®/gal	1.70 g	May 22
Dino + Pentra- Bark® trunk spray	Garden sprayer; 3.2 fl oz/inch DBH	Safari (20%) + 3 oz Pentra-Bark®/gal	1.70 g	May 22