Evaluation of Insecticides for Controlling the Asian Longhorned Beetle, *Anoplophora glabripennis* - a Synthesis Presentation

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Abstract

Since 1998, we have evaluated different insecticides as well as various application methods for the control of the Asian longhorned beetle (ALB), *Anoplophora glabripennis*. Evaluations have been conducted by two separate cooperative projects in China, one between USDA Animal Plant Health Inspection Service (APHIS) Otis Laboratory, USDA Forest Service (FS) Forest Health Technology Enterprise Team, Morgantown and the Chinese Academy of Forestry Institute of Forest Ecology Environment and Protection (CAF IFEEP), the other between USDA FS North Central Research Station and CAF IFEEP. In addition to the studies in China both the Otis laboratory and the North Central Research Station have conducted research in the U.S. This presentation summarizes all major activities and results of the above mentioned work.

1. Cover Insecticides Tested in China by APHIS Otis Laboratory and IFEEP

In 1999, eight insecticides (bifenthrin, deltamethrin, permethrin, acephate, chlorpyrifos, lindane, bendiocarb, and fipronil) were evaluated. Four concentrations were tested for each insecticide. Two insecticides, permethrin and fipronil, were tested for their residual effect. These insecticides were applied by cover spray onto twigs of trees, which were then cut and presented to adult beetles. The 2-day total adult ALB mortality was 100% for all insecticides tested except for bifenthrin (biflex 2EC, 0.02 ml/l), which was 63.3%. However, Mortality of adult ALB dropped to 30% when they were exposed to treated twigs collected more than 2 weeks post-treatment. In 2000, four insecticides (permethrin, chlorpyrifos, sevin, and acephate) were tested for short term and residual effects on adult ALB, the results again showed high mortality, but poor residual after 2 weeks, although there were some differences among the insecticides.

2. Systemic Insecticides tested in China by APHIS Otis Laboratory and IFEEP

a. Systemic insecticides and application methods

A total of nine insecticides with different application methods have been tested for their systemic action since 1998. The insecticides included: (1) imidacloprid, (2) methamidophos, (3) disyston, (4) metasystox–r, (5) acephate, (6) acetamiprid, (7) thiacloprid, (8) bidrin, and (9) thiamethoxam. The delivery methods evaluated were soil injection (Kioritz & pressurized soil injector; with or without prior watering of the soil) for disyston, imidacloprid, metasystox–r, methamidophos, and thiamethoxam; trunk injection (Mauget) for acetamiprid, bidrin, imidacloprid, metasystox-r, and thiacloprid; and trunk implant (Acecaps & Medicaps) for imidacloprid and acephate. Insecticides were applied in March, April, May, June, July, September, and October. Generally, imidacloprid applied through trunk and soil injection showed the most promise for ALB adult control. Acetamiprid through trunk injection and thiamethoxam through soil injection resulted in similar efficacy to ALB adults with imidacloprid. However, larval mortality (especially, later instars) was found to be low for all insecticides tested.

b. Dose-response of ALB adults and larvae to imidacloprid

The LC_{50} values for the applied level of imidacloprid to adult beetle were 87.4 ppm, 43.1 ppm, and 27.3 ppm at 24h, 48h, and 72h, respectively. These values correspond to 5.0, 2.9 and 1.9 ppm for the actual level of imidacloprid detected in the twigs. Our results indicated that mortality of adult beetles resulted not

only from oral and contact poison, but also from their refusal to feed. Although the dose-response test of ALB larva to imidacloprid is still in progress, preliminary results indicated that it would take 6-7 weeks to achieve 50% larval mortality even with high doses (>50 ppm applied, >0.50 ppm detected). Antifeedant activity of imidacloprid to ALB larvae was also observed.

c. Translocation of imidacloprid in trees
Samples of leaves, twigs and bark/xylem of tree trunks were collected from as early as 15 days to more than 2 years post imidacloprid treatments. Imidacloprid levels detected trees differed with different application dates and delivery methods. In some cases, the imidacloprid level detected in all tree parts exceeded the LC_{50} within one month post application and remained above the LC_{50} level several months to one year after application. However, levels of imidacloprid in trees were from non-detectable to around 0.5 ppm 2 years after application.

3. Systemic Insecticides tested in China by FS North Central Station and IFEEP

a. Systemic insecticides and delivery methods
Imidacloprid (10% and 15% a.i., and thiacloprid (10%, and 15% a.i.) through trunk injection using Mauget devices, emamectin benzoate through trunk injection using shot one bottles and azadirachtin (4% a.i.) through systemic tree injection tubes were applied to elm, poplar and willow trees in 2000. Half of the trees were felled 4 months post-injection and the remaining trees were felled 1-year post injection. Mortality of all stages of ALB was assessed. Although there were differences among tree species in terms of ALB mortality, average mortality of all stages combined for all tree species were: imidacloprid = 22.1%; emamectin benzonate =16.7%, azadirachtin = 11.3% and control = 7.9%. The mean number of dead adults found under elm and poplar trees were 67.5, 31.5, 8.8, 35.9 for trees treated with imicide, 10% thiacloprid, 15% thiacloprid and azadirachtin, respectively, and 13.6% for the control.

b. Translocation of imidacloprid and other chemicals
Samples of leaves and twigs of elm, poplar and willow were collected 4 weeks post injection of imidacloprid and azadirachtin and analyzed to determine the level of each compound. Residues level were found to range between 1.10 (willow twig)-1.54 ppm (elm twig) for imidacloprid and from 1.21 (willow twig) to 30.65 ppm (elm leaf) for azadirachtin.

In an attempt to understand the translocation of insecticide, especially, imidacloprid in trees, poplar and willow trees were injected with acid fuchsin stain. Injected trees were felled and dissected 24 h later and the presence of dye was examined. It was found that the presence of dye was variable along main trunk and there was no clear trend with height above injection site, indicating dye moved up and down. Dye penetrated up to four rings deep, but did not reach the cambium until 2 m above the injection site.

4. Systemic insecticides tested in the US by APHIS Otis Laboratory

a. Mortality of adult ALB feed on twigs of Norway maple nursery stock treated with imidacloprid through either soil injection (Merit 75WP), or trunk implant (Medicaps) or treated with trunk implant of acephate (Acecaps) were compared in 1997. Soil injection of merit 75 WP killed more adults than trunk implants.

b. In 1999, insecticides were applied to red and sugar maple through different delivery methods (imidacloprid through Mauget, wedgle, Acecaps, soil injection, abamectin through wedgle, bidrin through Mauget). Samples of twigs, leaves, and wood were collected 2-4 months post-application and imidacloprid levels were determined. The highest level of imidacloprid (2.1 ppm) was detected in wood of trees treated with imidacloprid through Mauget injection devices. Abamectin through wedgle, and bidrin through trunk injection did not yield detectable levels of each insecticide.

c. In 2000, imidacloprid was injected into trunks of red maple using CO2 tree tunk injection system at 300 PSI. Samples of tree parts were collected 2 weeks, 4 weeks, and 8 weeks post application, and imidacloprid levels were determined. This injection system is time consuming and resulted in non-detectable level (<0.03 ppm) of imidacloprid in trees. Also in 2000, different Mauget imicide treatment methods (i.e., deep vs shallow, 1 hr vs 2 hrs vs 3 hrs vs 4 hrs delivery time) were compared. No significant differences were found among treatment methods in terms of imidacloprid levels in trees 1-month post application.

d. In 2001, the efficacies of prophylactic treatments with imidacloprid (Mauget imicide and soil injection) were evaluated in IL and NY. In addition, imidacloprid treatment methods (drench, granular and soil plug) for containerized stock in two species of trees (birch, Japanese red maple) were evaluated. Comparison of Mauget imicide and Merit 75 WP soil injection (with and without wetting agent) in

spring and fall was initiated in NY. Chemical analysis to determine imidacloprid levels in these trees is still in progress.

e. In 2001, levels of imidacloprid in leaf, twig and wood of different sizes (small =2-4" DBH, medium = 8-11" DBH, large = 12-32" DBH) of trees (American and slippery elm, Norway and silver maple, white ash) were compared 2 months post application for 3 different application rates (doses). The results indicated that higher application rates often yielded higher levels of imidacloprid in trees. Levels of imidacloprid were much higher in small trees than large ones. Generally, levels of imidacloprid detected in elm were higher than those in maple, which were higher than those in ash.

5. Systemic Insecticides tested in the US by FS North Central Station

a. Laboratory bioassay of imidacloprid and thiamethoxam.
In 1999, American elm, poplar, silver maple, and boxelder were treated with imidacloprid (through Mauget, Acecaps, Wedgle, and soil injection using the Kioritiz injector), and thiamethoxam (soil injection using the Kioritiz injector). Mortality of larvae transferred into branches of trees of different treatment were compared. The highest mortality was found for larvae transferred into boxelder treated with Maugets (= 70%).

Another bioassay was conducted in 2000. Insecticides (imidacloprid through Mauget and Kioritz soil injector, emamectin benzoate through Shot One bottles, and azadirachtin through systemic tree injection tubes) were injected into silver maple and boxelder. Overall mortality for ALB larvae transferred into branch sections of treated trees was very low. Samples of leaves, twigs and wood were collected. Residue analysis to determine levels of imidacloprid, emamectin benzoate, and azadirachtin are still underway.

b. ALB and cottonwood borer larvae reared on diet treated with imidacloprid and neem extracts.
Larvae of ALB and cottonwood borer were fed with artificial diet mixed with several concentrations of imidacloprid and azadirachtin extracts. The results indicated that both insecticides have strong antifeedant effects. It took 12 weeks to achieve 100% mortality on the highest doses and some mortality also occurred on the lowest doses.