Control of Red Elm Bark Weevil (*Magdalis armicollis*) in American Elm (*Ulmus americana*) by Trunk Injection of Azadirachtin

Michael Booth and Mark Goettel

Abstract. Trunk injection of azadirachtin into elm trees (*Ulmus americana*) using the Ecoject™ Microinjection System to reduce emergence numbers of red elm bark weevil (*Magdalis armicollis*) was evaluated. Twelve mature trees were each injected with TreeAzin™ in early August 2010 at a rate of 16 ml per 15.2 cm trunk circumference at breast height. The following year, weevil activity was monitored at weekly intervals for four weeks using sticky traps placed in the canopies. There was a significant reduction of 55%–60% in weevil activity in early summer in the treated tree canopies as compared to the control, suggesting that this method may be an effective management tool for this pest.

Key Words. American elm; *Azadirachta indica*; Ecoject™ Microinjection System; *Magdalis armicollis*; Neem; Red Elm Bark Weevil; Sticky Trap Sampling; TreeAzin™; Trunk Injection; *Ulmus americana*.

METHODS AND MATERIALS

Experimental Design
The experimental units were 24 mature trees, part of a row planting. These trees are on federally owned and managed property near Hwy #3, east of Lethbridge, Alberta, Canada. Twelve trees were treated, and 12 acted as controls. The experimental design consisted of four treatment trees followed by four control trees followed by four treatment trees and so on, creating three treatment groups of four trees each and three control groups of four trees each. Trunk circumference at breast height of the 24 trees ranged between 109 cm to 218 cm (mean = 156 cm).

Injection Treatment
The target application rate was 16 ml of TreeAzin Systemic Insecticide (5% azadirachtin; BioForest Technologies, Sault Ste. Marie, ON)/15 cm trunk circumference at breast height. Trees were measured and assigned a number of injectors based on tree size: two, 8 ml injectors per 15 cm of trunk circumference. The Ecoject injection tool pressurizes small plastic vials that inject small amounts of insecticide into the tree through holes drilled into the tree.

Azadirachtin, extracted from the neem tree (*Azadirachta indica*), is known to possess systemic activity against several defoliating and leaf-mining insects when injected into trees (Helson et al. 2007). It is registered in the United States as TreeAzin™ for use against the emerald ash borer and other foliar-feeding tree pests (EPA Reg. No 82996-1). Researchers evaluated trunk injection of azadirachtin into elm trees using the Ecoject Microinjection System as a means to reduce emergence numbers of the REBW at the Lethbridge Research Centre.
was approximately 0.38 MPa at the start of the loading stroke and 0.45 MPa at the end of the stroke. Each injector delivered the entire contents into the tree within 10 to 15 seconds. Injection holes were then filled with silicone sealant. Injection was conducted between 8:00 a.m. and 12:00 noon on August 4 and 5, 2010. Conditions were as follows: August 4: at start 13°C, RH 89%, wind 4 km/h; at end 20°C, RH 53%, wind 4 km/h; Aug 5: at start 15°C, RH 86%, wind 4 km/h; at end 22°C, RH 54%, wind 13 km/h.

**Sampling**

**Insects**

Five yellow “Tanglefoot” (Conotech Industries, Delta, British Columbia, Canada) sticky traps 10 cm × 15 cm were established in each tree in the year following insecticide applications. A total of 120 traps were hung from branches 10 to 12 m above ground level at the beginning of each sampling period using a man lift, then removed and returned to the laboratory for counting the number of adult REBW. Collection and replacement of traps was conducted until populations generally declined. Samples were taken one, two, three, and four weeks following detection of REBW. Traps were established in trees June 29–30, 2011, and sampling commenced between July 6 and 7, 2011.

**Statistical Analysis**

Data were analyzed using three reps for each treatment after calculating the means over the four subsamples. In addition, data were analyzed using only the two inner tree subsamples to determine possible effect of infiltration of emerging adults among treated and untreated trees, with the two outside trees acting as buffers. In both analyses, there were two treatments, four sampling times, and three reps available. The subsamples were gone after taking the means. A repeated measures analysis was used to account for possible correlations among sampling times. The data were analyzed using PROC MIXED (SAS Institute, Inc. 2008), with “treatment,” “time,” and their interaction treated as fixed effects and “rep×treatment” as the random effect. Since the same trees were sampled four times, “time” was treated as a repeated measure and various variance-covariance error structures were fitted and the one with the lowest AICC value was used in the final analysis. The analyses were done using the mean number of insects collected per card because the number of cards was not consistent across trees or sampling time due to periodic blowdown of traps. The UNIVARIATE procedure was used to check the residuals for normality and for potential outliers before performing the final analysis.

**RESULTS AND DISCUSSION**

There was a significant interaction between treatment and time when all four subsamples were considered (df = 1,12; F = 4.47; P = 0.025) as well as when only the two inner trees were considered (df = 1,12; F = 3.27; P = 0.05). In the first week, 55% fewer weevils were trapped in the treated trees as compared to the untreated trees when all four subsamples were considered (Figure 1) and 60% when only the two inner trees were considered (df = 1,12; F = 3.27; P = 0.025) as well as when only the two inner trees were considered (df = 1,12; F = 3.27; P = 0.05). In the first week, 55% fewer weevils were trapped in the treated trees as compared to the untreated trees when all four subsamples were considered (df = 1,12; F = 3.27; P = 0.025) as well as when only the two inner trees were considered (df = 1,12; F = 3.27; P = 0.05). In the first week, 55% fewer weevils were trapped in the treated trees as compared to the untreated trees when all four subsamples were considered (df = 1,12; F = 3.27; P = 0.025) as well as when only the two inner trees were considered (df = 1,12; F = 3.27; P = 0.025) as well as when only the two inner trees were considered (df = 1,12; F = 3.27; P = 0.025) as well as when only the two inner trees were considered (df = 1,12; F = 3.27; P = 0.025). In the first week, 55% fewer weevils were trapped in the treated trees as compared to the untreated trees when all four subsamples were considered (df = 1,12; F = 3.27; P = 0.025) as well as when only the two inner trees were considered (df = 1,12; F = 3.27; P = 0.025). In the first week, 55% fewer weevils were trapped in the treated trees as compared to the untreated trees when all four subsamples were considered (df = 1,12; F = 3.27; P = 0.025) as well as when only the two inner trees were considered (df = 1,12; F = 3.27; P = 0.025). In the first week, 55% fewer weevils were trapped in the treated trees as compared to the untreated trees when all four subsamples were considered (df = 1,12; F = 3.27; P = 0.025) as well as when only the two inner trees were considered (df = 1,12; F = 3.27; P = 0.025). In the first week, 55% fewer weevils were trapped in the treated trees as compared to the untreated trees when all four subsamples were considered (df = 1,12; F = 3.27; P = 0.025) as well as when only the two inner trees were considered (df = 1,12; F = 3.27; P = 0.025). In the first week, 55% fewer weevils were trapped in the treated trees as compared to the untreated trees when all four subsamples were considered (df = 1,12; F = 3.27; P = 0.025) as well as when only the two inner trees were considered (df = 1,12; F = 3.27; P = 0.025). In the first week, 55% fewer weevils were trapped in the treated trees as compared to the untreated trees when all four subsamples were considered (df = 1,12; F = 3.27; P = 0.025) as well as when only the two inner trees were considered (df = 1,12; F = 3.27; P = 0.025). In the first week, 55% fewer weevils were trapped in the treated trees as compared to the untreated trees when all four subsamples were considered (df = 1,12; F = 3.27; P = 0.025) as well as when only the two inner trees were considered (df = 1,12; F = 3.27; P = 0.025)

**Figure 1.** Mean trap count numbers of red elm bark weevils from treated and untreated American elm trees at Lethbridge, Alberta. Twelve trees were treated with TreeAzin Systemic Insecticide (5% azadirachtin) at a rate of 16 ml per 15 cm circumference using the Ecoject Microinjection System. Twelve trees acted as controls. Groups of four contiguous trees per replicate were alternated, creating three treatment groups and three control groups. Asterisk (*) denotes significant treatment effect (P < 0.05).

**CONCLUSION**

Late summer trunk injection with azadirachtin, using the Ecoject Microinjection System was shown to be effective in reducing red elm bark weevil emergence the following year in American elms. However, the treatments did not prevent infiltration of weevils from adjacent non-treated trees suggesting that all potential host trees in an area would need to be treated for adequate management of this pest.

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**LITERATURE CITED**


Michael Booth (corresponding author)
Lethbridge Research Centre
Agriculture & Agri-Food Canada
Lethbridge, Alberta, Canada
T1J 4B1
boothm@agr.gc.ca

Mark S. Goettel
Lethbridge Research Centre
Agriculture & Agri-Food Canada
Lethbridge, Alberta, Canada
T1J 4B1
bstedit@telusplanet.net

Résumé. L’injection dans le tronc d’ormes d’Amérique (Ulmus americana) de azadirachtin au moyen du Système d’Injection Ecoject™ afin de diminuer l’émergence du charançon de l’orme (Magdalis armicollis) a été évaluée. Douze arbres matures ont été injectés avec le TreeAzin™ au début de août 2010 à un taux de 16 ml par 15,2 cm de circonférence de tronc mesuré au DHP. L’année suivante, l’activité des charançons a été suivie à intervalle hebdomadaire durant quatre semaines au moyen de pièges collants disposés dans la couronne. Il y a eu une diminution significative de 55 à 60% de l’activité des charançons au début de l’été chez les arbres traités comparativement aux arbres-témoins ce qui suggérait que cette méthode peut être un outil efficace pour la gestion de ce parasite.

Zusammenfassung. Hier wurde die Stamminjektion von Azadirachtin in Ulmen (Ulmus americana) mithilfe des Ecoject™ Microinjection Systems zur Begrenzung der Schlupfzahlen des Roten Ulmen-borkenkäfers (Magdalis armicollis) bewertet. Zwölf ausgewachsene Bäume wurden jeder im frühen August 2010 in einer Rate von 16 ml pro 15,2 cm Stammumfang in Brusthöhe mit TreeAzin™ injiziert. Im folgenden Jahr wurde die Aktivität der Käfer in wöchentlichen Intervallen für vier Wochen mit Klebetafeln in der Krone überwacht. Es gab einen signifikanten Rückgang um 55-60 % bei der Aktivität der Käfer im Frühsommer bei den behandelten Bäumen im Vergleich zu Kontrolle, was bedeutet, dass diese Methode ein effektives Werkzeug zur Kontrolle dieses Schädlings sein kann.

Resumen. Se evaluó la inyección al tronco de azadirachtin en árboles de olmo (Ulmus americana) usando el sistema de microinyección Ecoject™ para reducir el número de emergencia de barbonadores (Magdalis armicollis). Se inyectaron doce árboles maduros con TreeAzin™ a principios de Agosto de 2010 a una tasa de 16 ml por cada 15,2 cm de circunferencia del tronco a la altura del pecho. En el siguiente año la actividad del insecto fue monitoreada a intervalos semanales por cuatro semanas usando trampas pegajosas localizadas en la copa. Hubo una reducción significativa de 55%–60% en la actividad del insecto en el verano temprano en los árboles tratados, comparados con los controles, sugiriendo que este método puede ser una importante herramienta de manejo para esta plaga.