COTTONWOOD LEAF BEETLE CONTROL WITH IMIDACLOPRID SOAKED CUTTINGS

Terry L. Robison and Randall J. Rousseau[1]

Abstract—Dormant, unrooted cuttings from three eastern cottonwood (*Populus deltoides* Marsh.) clones were soaked in either water or one of two concentrations of Admire® 2 Flowable (imidacloprid) insecticide. Half were planted immediately after soaking while the other half were stored for 12 weeks at -2°C prior to planting. Trees from cuttings soaked in either the 0.053 or 0.106 percent imidacloprid solutions were significantly taller at each measurement date and had lower levels of insect feeding than trees from cuttings soaked in water. Insect feeding on shoot terminals was limited almost entirely to the control trees (water soaked). Treatment effects lasted for over 14 weeks, but insect population levels were low at the end of the growing season limiting damage. In a related observational study, imidacloprid treatment effects seemed to carry into June of the second growing season.

INTRODUCTION

Cottonwood leaf beetle (*Chrysomela scripta* F.) is a major defoliator of *Populus* plantations (Abrahamson and others 1977, Burkot and Benjamin 1979, Coyle and others 2005) with preferred clones containing parentage from the Aigeiros or Tacamahaca sections (Caldbeck and others 1978, Harrell and others 1981, Bingaman and Hart 1992). Both cottonwood leaf beetle (CLB) adults and larvae feed on young leaves, with larvae causing the most damage. When population numbers are high, larvae may completely consume young leaves and shoot tips. Because CLB have up to five generations per year (Coyle and others 2005), high population levels can be attained quickly under favorable conditions (Bingaman and Hart 1992) such as warm, extended growing seasons (Mattson and others 2001). Near the confluence of the Mississippi and Ohio Rivers, we have observed intense CLB feeding pressure from bud break throughout the growing season.

Eastern cottonwood makes its most rapid growth during the first three years after planting. Plantations are particularly susceptible to CLB infestations during this period because of the high percentage of succulent leaf and stem tissue (Bingaman and Hart 1992, Coyle and others 2005, Fang and Hart 2000). An artificial defoliation study showed that during the first two growing seasons *Populus* growth and biomass may be reduced by one-third when defoliation reaches 75 percent (Reichenbacker and others 1996). Recent field studies indicate that heavy CLB defoliation (approaching 100 percent) during the first two years resulted in height and diameter growth losses greater than 50 percent (Mattson and others 2001, Coyle and others 2002).

Carbofuran, chlorpyrifos, carbaryl, dimethoate, and various *Bacillus thuringiensis* Berliner (*Bt*) endotoxin formulations have been effective in controlling CLB (Coyle and others 2000). Carbofuran provided long-term control of CLB and other cottonwood pests such as the cottonwood borer (*Plectodera scalatum*) because of its long soil residual and systemic activity. However, this chemical is no longer labeled for use on cottonwood. Carbaryl, chlorpyrifos, and dimethoate are labeled for CLB control, but mounting pressure to further restrict these pesticides may limit their use. *Bt* products (Coyle and others 2000) and carbaryl are highly effective, but their residual activity is low and repeated applications are needed to maintain adequate control levels. Application timing is critical, and often insecticides are applied after substantial damage has occurred. Residual and systemic actions are desirable insecticide traits.

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Studies in the Pacific Northwest indicate Admire® 2 Flowable (imidacloprid), also a systemic insecticide, applied through drip systems was highly effective in reducing population abundance of CLB and aphids [*Phylloxerena popularia* (Pergrande)] (Unpublished data, Douglas Walsh, Department of Entomology, Washington State University, Irrigated Agriculture Research and Extension Center, Prosser WA). These results were used to obtain a supplemental label for Admire® 2 Flowable for use on *Populus* in Oregon and Washington.

Imidacloprid was introduced in the early 1990s as the first chloronicotinyl insecticide. It disrupts an insect's nervous system by acting as a competitive inhibitor at nicotinic acetylcholine receptors (Liu and Casida 1993). It is the most widely used insecticide in the world with various formulations used in over 120 countries on more than 250 crops (Personal communication. 2004. David Rogers, Product Development Manager, Bayer CropScience, Product Development, P.O. Box 12014, Research Triangle Park, NC). The wide acceptance is founded on the effectiveness of the chemical, the safety to its handlers, and its enhanced environmental safety. Studies show imidacloprid undergoes complete biotic degradation in the soil, degradation is enhanced by sunlight, there is little soil accumulation even with repeat applications, and it does not persist in aqueous environments (Krohn and Hellpointner 2002). It is highly toxic to bees and house sparrows; moderately toxic to aquatic invertebrates, upland game birds, and earthworms; and slightly to not toxic to fish and waterfowl (Anon. 2003, Elbert and others 1990, U.S. Environmental Protection Agency 1994).

"Seed-piece" soaking is used for treating sugarcane stalks, *Saccharum* sp., and seed potatoes (*Solanum tuberosum* L.) with imidacloprid prior to planting. In these cases, the sugarcane stem section or potato "seed-piece" serves as the reservoir for the chemical instead of the soil. This method may work similarly with dormant, unrooted cottonwood cuttings. Cost per cutting would be substantially less using this method versus applying imidacloprid directly to the soil. Moreover, potential toxic effects to bees, birds, and fish would be minimized. Because this application method has not been tested previously on cottonwood, we evaluated its use on a sample of operational clones to determine its effectiveness and detect potential harmful effects such as reduced survival. Because storage times for operational cuttings can vary from zero to 25 weeks, we also wanted to test the effects of storage on chemical stability and insect control.

PROCEDURES

The study was located on an unprotected (located between levee and Mississippi River), alluvial site in Pemiscot County, Missouri that was previously in row crops. The soil is Commerce silty clay loam, which is considered excellent for cottonwood growth. Site preparation consisted of disking followed by row marking and sub-soiling at 3.66 m intervals. The experiment was arranged in a factorial design with randomized complete blocks. Cottonwood clones (3 clones), planting dates (2 dates), and Admire® 2 Flowable solution concentrations (3 levels) were the three factors combining for a total of 18 treatments. A nine-tree row plot represented each treatment in each block for a total of 72 plots. A three-tree border planted with untreated cuttings separated plots. Dormant, unrooted cuttings from three MeadWestvaco clones (WV000099, WV000413, and WV000426) were submerged for 17 hours in 0, 0.053, or 0.106 percent Admire® 2 Flowable solutions. To verify stability of the insecticide, one-half of the cuttings were planted immediately after soaking (February 27, 2004), and the other half were planted after approximately 12 weeks of storage at -2°C (May 21). Cuttings were planted at intervals of two feet along the sub-soiled rows.

Insect presence and leaf feeding damage were assessed every seven to 25 days to evaluate treatment effects. Assessment began on May 12 and June 3 for the first and second planting dates, respectively, and lasted through October 6. Total height was measured to the nearest 0.1 m on July 15, September 1, and October 6. CLB presence was recorded using the following categories:

0 = no insects
1 = CLB eggs
2 = 1st instar
3 = 2nd instar
4 = 3rd instar
5 = adult
6 = other feeding insect

Feeding damage was rated on the top eight leaves (LPI 1-8) (Larson and Isebrands 1971) using the following scale (Coyle and others 2002, Fang and Hart 2000):

0 = no feeding on LPI 1-8
1 = light feeding; sample feeding to < 33 percent LPI 1-8 missing
2 = light to moderate feeding; 33-50 percent of LPI 1-8 missing; main leader intact
3 = moderate to heavy feeding; 50-75 percent of LPI 1-8 missing; main leader intact
4 = heavy feeding; > 75 percent of LPI 1-8 missing; main leader and terminal bud heavily damaged or destroyed

Arcsine transformations of individual plot proportions were computed for insect presence, substantial feeding damage (score >2), and terminal damage (score =4) on all survey dates and for end of year survival. Analysis of variance for arcsine transformations and height data were generated using PROC GLM, SAS/STAT software (Version 8.1 of the SAS System for Windows. Copyright ® 1999-2000 SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA).

RESULTS AND DISCUSSION

Survival

On October 6, 2004, overall test survival was 92 percent. Significant survival differences were detected for planting date (P<0.01) and clone (P<0.001). Survival for the February 27 planting was 94 percent but dropped to 90 percent for the May 21 planting date. The decrease in survival is more likely related to environmental conditions at the May planting date than to cutting storage conditions. Overall clone survival was 98, 96, and 82 percent for WV000099, WV000413, and, WV000426, respectively. Based on previous experience, the decreased survival for clone WV000426 is an anomaly, and may have resulted from poor handling or improper storage prior to assembling the test. Most important, no differences were detected for survival of any clone at the various Admire® 2 Flowable concentrations (P>0.99), which indicates that the chemical had no detrimental effects on this sample of operational clones at these concentrations.

Height Growth

Height was significantly greater (P<0.001) for trees receiving either Admire® 2 Flowable treatment than control trees at all measurement dates for both planting dates (fig. 1). The 0.053 percent and 0.106 percent treatments did not differ from each other on any measurement date. End-of-season heights for treated trees averaged 30 to 60 cm greater than control trees for the early-planted and late-planted trees, respectively. No second or third order interactions were significant, but heights varied significantly among clones at the final measurement date (P<0.01). Regardless of soaking treatment concentration, WV000099 was taller than the other two clones at each measurement date for each planting date, and the difference became greater later in the season (fig. 2).

CLB Populations and Feeding Damage

Insects first appeared in noteworthy numbers around May 21 on trees planted February 27, approximately one month after bud break (table 1). Initially, insecticide treated plots had fewer trees with CLB than the control plots. In June, CLB levels increased dramatically, and we found CLB on nearly all treated trees and on 79 percent of the control trees during the June 21 survey. The lower CLB presence may have

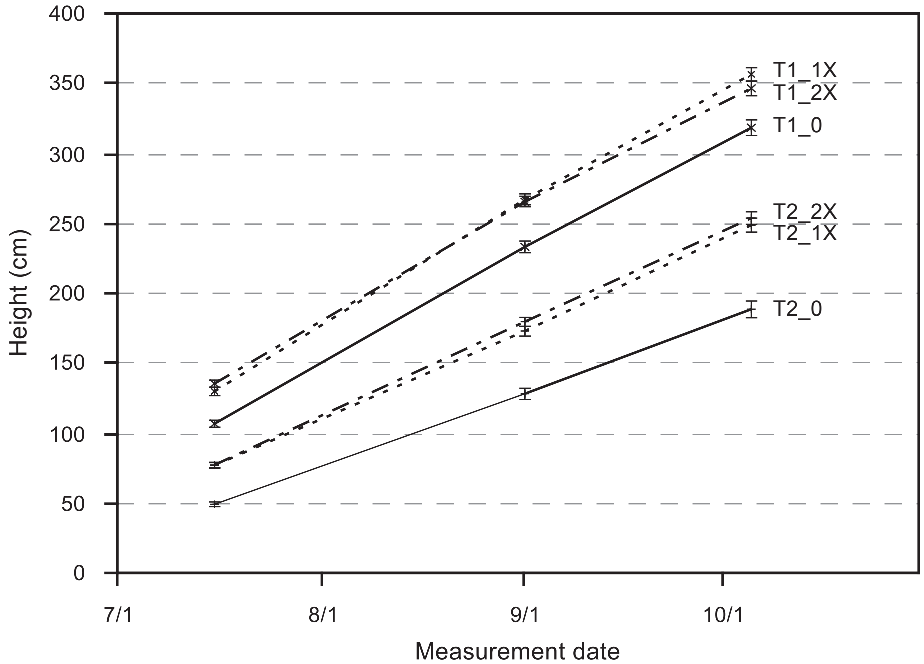

Figure 1—Mean height by planting date (T1 = 2/27/04 top three lines; T2 = 5/21/04 bottom three lines) and Admire® 2 Flowable soaking concentration (0 = 0 percent, 1x = 0.053 percent, 2x = 0.106 percent) for all trees. Bars indicate mean standard error.

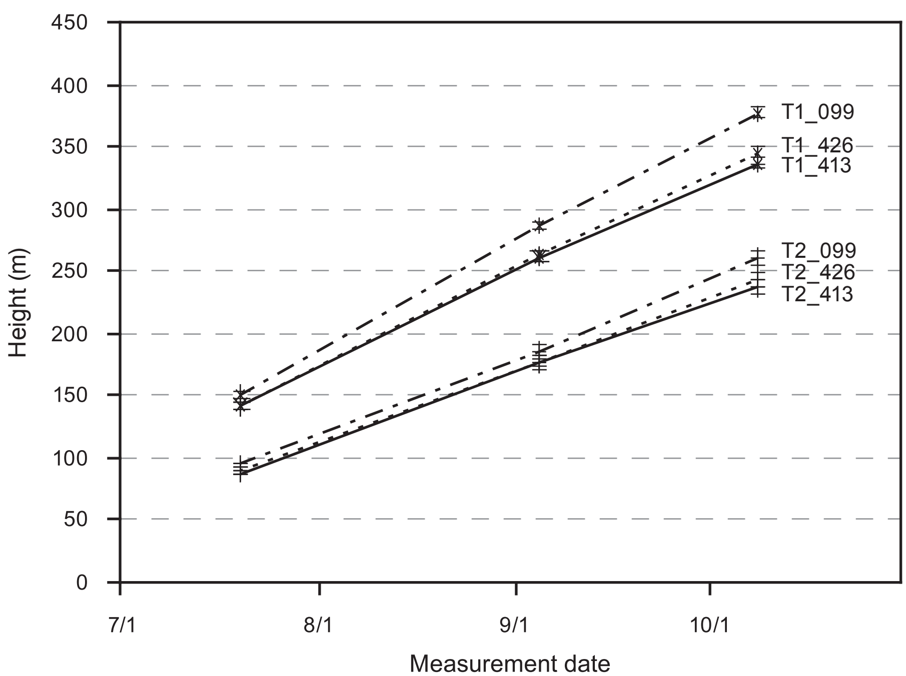

Figure 2—Mean height by planting date (T1 = 2/27/04 top three lines; T2 = 5/21/04 bottom three lines) and clone (WV000413, WV000426, and WV000099). Bars indicate mean standard error.

Table 1—Mean percent trees with leaf–feeding insects, with feeding damage score > 2 (affecting 33 percent of top eight leaves), and with feeding damage score > 4 (terminal shoot damage) for trees treated with either 0 percent, 0.053 percent, or 0.106 percent Admire® 2 Flowable insecticide and planted February 27, 2004 (clones were combined for this analysis)

	Trees with leaf–feeding insects (mean %)			Trees with feeding damage score > 2 (mean %)			Trees with feeding damage score = 4 (%)		
	Admire® 2 Flowable soaking solution concentration								
Date	0	0.053%	0.106%	0	0.053%	0.106%	0	0.053%	0.106%
May 12	1a	0a	0a	1a	0a	0a	0a	0a	0a
May 21	54a	28b	15c	9a	0b	0b	3a	0b	0b
May 26	60a	35b	31b	13a	0b	2b	4a	0b	0b
June 3	60ab	67a	53b	30a	2b	1b	5a	0b	0b
June 10	85a	87a	77a	37a	3b	2b	3a	0b	0b
June 21	79a	97b	99b	100a	94ab	83b	40a	3b	2b
July 6	37a	33a	22b	38a	27ab	12b	5a	0b	0b
July 15				23a	4b	7b	1a	0a	0a
August 4	4a	2a	2a	2a	0a	0a	0	0	0
September 1	35a	39a	31a	0a	1a	0a	0	0	0
September 16	26a	22a	21a	1a	0a	0a	0	0	0

Note: mpty cells indicate data not collected for that variable and date.
For a particular date and variable, means followed by the same letter are not significantly different (0.05) using Tukey's HSD.

resulted from increased terminal damage on control trees resulting in less desirable leaf tissue available to CLB than on the less damaged, treated trees. In early August, levels dropped and remained low until an outbreak of CLB in early September. During the October 6 height measurements, CLB levels were very low and incidence data were not collected.

Cuttings planted May 21 developed quickly with bud break initiating within one week. CLB populations were low on the developing cuttings, but from June 3 to June 21 the percentage of trees with CLB climbed steadily on the control trees to over 80 percent (table 2). Less than 30 percent of the treated trees (either concentration) had CLB at this date. As with the February planted trees, CLB populations then dropped until an outbreak in early September when fewer control trees had CLB than the treated trees.

Substantial feeding damage was defined as occurring when CLB feeding affected more than 33 percent of the top eight leaves (feeding damage scores ≥ 2). Throughout the season, the percent of trees with substantial feeding damage was always greater on control trees than on treated trees for both planting date with the 0.106 percent treatment showing the least damage in most instances. For the trees planted in February, feeding damage on treated trees approached that of the control trees only in late June and early July when CLB populations were the highest (table 1). On June 21, 100 percent of the control trees had feeding damage while 94 percent and 83 percent of the 0.053 percent and 0.106 percent treatment trees, respectively, had damage. Damage to insecticide treated trees planted in May was always much lower than the control trees except late in the year when feeding damage was found on less than 10 percent of trees across treatments (table 2).

Regardless of planting date, very few trees in the 0.053 percent or 0.106 percent treatments had terminal damage (feeding score = 4) indicating that Admire® 2 Flowable nearly eliminated heavy CLB feeding in

Table 2—Mean percent trees with leaf–feeding insects, with feeding damage score > 2 (affecting 33 percent of top eight leaves), and with feeding damage score > 4 (terminal shoot damage) for trees treated with either 0 percent, 0.053 percent, or 0.106 percent Admire® 2 Flowable insecticide and planted May 21, 2004, after 12 weeks of storage at -2 °C (clones were combined for this analysis)

	Trees with leaf–feeding insects (mean %)			Trees with feeding damage score > 2 (mean %)			Trees with feeding damage score = 4 (mean %)		
	Admire® 2 Flowable soaking solution concentration								
Date	0	0.053%	0.106%	0	0.053%	0.106%	0	0.053%	0.106%
June 3	1a	0a	0a	0	0	0			
June 10	30a	5b	2c	5a	0b	0b	0	0	0
June 21	81a	28b	28b	64a	0b	0b	19a	1b	0b
July 6	30a	19a	21a	52a	1b	0b	11a	0b	0b
July 15				29a	1b	0b	6a	0b	0b
August 4	2a	4b	6b	4a	1b	3ab	2a	0b	1ab
September 1	43a	49ab	60b	9a	3b	4b	1a	0a	0a
September 16	31a	16b	16b	13a	3b	4b	3a	0b	0b

Note: empty cells indicate data not collected for that variable and date.
For a particular date and variable, means followed by the same letter are not significantly different (0.05) using Tukey's HSD.

this study (tables 1 and 2). Even during the June 21 survey date when population and feeding levels were high, terminal feeding remained low on treated trees. These observations indicate that imidacloprid is directed to the growing points of the plant and concentrated in the actively growing shoot tips. These data and observations show that imidacloprid does not prevent CLB from colonizing cottonwood leaves. The beetles are often found in large numbers on treated trees, but their feeding activity is limited, especially at the actively growing shoot tips.

Observations

Both Admire® 2 Flowable soaking treatments resulted in reduced feeding damage, especially terminal damage, and increased height growth compared to the control. CLB control lasted at least through July 15 as indicated by the reduced levels of damage and terminal feeding on treated trees compared to the controls. This translates to almost 14 weeks of control from bud break for the first planted trees. Reduced CLB numbers and damage levels throughout the test later in the growing season made it difficult to determine whether CLB control continued longer in this test. In other crops, the length of control is related to application rates, and it may be possible to extend control past 14 weeks using higher solution concentrations (Personal communication. 2004. David Rogers, Product Development Manager, Bayer CropScience, Product Development, P.O. Box 12014, Research Triangle Park, NC). Indeed, trees treated with 0.212 percent Admire® 2 Flowable in an observational trial near Wickliffe, Kentucky had far less CLB damage than controls through June of the second growing season.

Leaves on treated trees appeared glossy compared to control tree leaves especially during the first one-third of the growing season. This appearance was also observed in the observational trial. Bayer CropScience supports this observation indicating that along with the healthier appearance of plants, yield data shows that when compared to other insecticides, Admire® 2 Flowable enhances growth of other crops beyond that attributed to insect control (see www.BayerAdmire.com). In our study, the low to moderate CLB populations during the growing season might imply that the growth enhancement for treated trees could be attributed partially to the insecticide treatments. More detailed studies comparing growth rates using this and other insecticides are needed to determine if this is true for cottonwood.

The effectiveness of soaking treatments regardless of planting date indicates that time in cold storage did not degrade the insecticide once imbibed by the cuttings. Moreover, the first planted cuttings were in the ground for almost two months prior to growth initiation. The chemical apparently was not leached or otherwise degraded during this period. Both of these observations are consistent with manufacturer claims regarding low volatilization, tight soil binding, and slow breakdown in the absence of light. The tight soil binding characteristics seem to be reflected in the binding within the cuttings.

Cost Analysis

Admire® 2 Flowable is an expensive insecticide for forestry use considering the 473 to 976 mL/ha rates currently recommended for cottonwood when applied through drip irrigation or when knifed into the soil. At $153/L, these methods cost $180 to $358/ha for the chemical alone suggesting that it should be used only on high-value plantings such as nurseries. However, the soaking treatment described herein reduces the chemical cost to $2.55/ha using a 0.106 percent solution concentration and the highest uptake rate calculated from pre- and post-soaking cutting weights (21 mL solution per cutting). At a spacing of 3.66 m square, this translates to less than 16.7 mL/ha Admire® 2 Flowable at a cost of $0.0034 per cutting. The cost of handling, including soaking tank development, will increase the actual application cost.

An improved chemical formulation has been released with an expanded label that includes methods described in this paper. The new product formulation, Admire® Pro Systemic Protectant, provides better mixing properties eliminating foaming and tank residue.

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