EFFECTS OF ARTIFICIAL DEFOLIATION ON THE GROWTH OF COTTONWOOD: SIMULATION OF COTTONWOOD LEAF BEETLE DEFOLIATION

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Abstract—*Populus* are among the fastest growing commercial forest trees but are not without problems. Insects and diseases can take their toll. The cottonwood leaf beetle (*Chrysomela scripta* F.; CLB) is of concern. Although damage by the CLB can result in terminal dieback, reduction in growth, and potential mortality, the impact on *Populus* growth and biomass accumulation is relatively scarce. This study was conducted near Cruger, MS, in a 2-year-old *Populus* plantation that had red oak seedlings interplanted. To assess the impact of CLB defoliation, varying levels of defoliation were applied during 2000. Defoliation at all levels had a significant effect on height growth. On average, undefoliated trees were significantly taller than defoliated trees. Trees defoliated at the rates of 50 percent and 75 percent exhibited the greatest decrease in growth. Height growth for trees defoliated at these levels was reduced by 30 and 31 percent, respectively. Trees defoliated at 25 percent were reduced in growth by 24 percent when compared to controls.

INTRODUCTION

Populus spp., some of the fastest growing commercial forest trees in North America with rotations of 6 to 12 years on good sites, grow well on the alluvial soils of the Lower Mississippi Alluvial Valley (LMAV). Uses of *Populus* range from wood products, fiber (pulp), and biomass energy to carbon sequestration. However, *Populus* are not without problems. Insects and diseases can take their toll on the cultivation of these trees. The primary insect pest of concern is the cottonwood leaf beetle (*Chrysomela scripta* F.), CLB. The CLB is a defoliator, with adults and larvae feeding on the young leaves and shoots of *Populus* species (Harrell and others 1982). Heavy feeding damage by the CLB can result in terminal dieback, reduction in growth (height, diameter), and potential mortality in young cuttings (Caldbeck and others 1978, Fang and Hart 2000).

Exact estimates of CLB defoliation impacts on *Populus* growth and biomass accumulation are relatively scarce. Bassman and others (1982), working on hybrid *Populus* in Wisconsin, found that moderate levels of artificial defoliation, mimicking CLB defoliation, had minimal effect on growth. However, severe levels of artificial defoliation caused marked decreases in height and diameter. Reichenbacker and others (1996) observed similar patterns, with *Populus* height, diameter, and aboveground biomass decreasing with increasing levels of defoliation. In the LMAV, comparable research on the impact of CLB defoliation on *Populus* is lacking. Information on CLB defoliation thresholds is needed because of the potential economic interest and impact that exists for *Populus* propagation in this region. The intent of this project was to determine the effects of artificial defoliation, designed to mimic the natural defoliation patterns of CLB, on the growth of *Populus* in a plantation setting within the LMAV.

SITES

This study was conducted in a 2-year-old *Populus* plantation in Leflore County near Cruger, MS. The plantation had been interplanted with red oak seedlings (*Quercus* spp.) and is enrolled in the Wetlands Reserve Program, with the intent of restoring a bottomland hardwood forest to this site.

PROCEDURES

Artificial Defoliation

To assess the impact of CLB defoliation, we applied varying levels of artificial defoliation to *Populus* during spring and summer 2000. We established 2 plot sizes within the plantation, small plots consisted of blocks of 4 trees, and large plots consisted of blocks of 16 trees. Treatments applied to small and large plots consisted of artificial defoliation at 25, 50, and 75 percent. Undefoliated trees were maintained as controls. Each treatment, along with controls, was replicated 3 times for a total of 12 small plots and 12 large plots.

We constructed a "defoliation device" that roughly mimics the pattern of defoliation inflicted on the tree by the CLB to artificially defoliate trees. The defoliation device consisted of a 4-foot PVC pole with three to four segments of rubber clothesline (10 to 16 inches in length) attached to the end. Tied to the ends of the segments were large treble hooks. When applied, the outer branches and leaves of the tree are struck with the hooks, causing leaf tissue to be torn and broken away.

Defoliation treatments were assigned randomly to plots. In order to assess defoliation levels, tree heights were measured. Assigned defoliation percent, based on that measured height, was determined from the top down, and the lower limit was marked with flagging. For example, the top 25 percent of a tree would be treated in the "25 percent

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defoliation" category. Only leaf plastochron index (LPI) 1 to 8 was damaged. Defoliation treatments were applied in May and August 2000.

Tree Measurement and Data Analysis

Diameter and total height were recorded pre- and post-treatment. Height was measured with an extension pole. Diameter was measured at 1 foot above the ground because many trees were too short to measure at diameter at breast height. Diameter was measured with calipers, with two measurements taken to produce an average value for each tree. The effect of defoliation treatment on height and diameter for measured trees was assessed using analysis of variance (ANOVA) and Fisher's PLSD (SAS Institute 1998).

RESULTS

Artificial defoliation at all levels had a significant effect on height growth when compared to control trees ($F = 14.417$; d.f. = 3,410; $P = <0.0001$). On average, undefoliated control trees were significantly taller than defoliated trees. Trees defoliated at 50 and 75 percent exhibited the most decreases in growth (fig. 1). Height growth for trees defoliated at these levels was reduced by 30 and 31 percent, respectively. Trees defoliated at 25 percent were reduced in growth by 24 percent when compared to controls.

Whereas artificial defoliation appeared to have no significant effect on diameter growth ($F = 1.762$; d.f. = 3,102; $P = 0.1592$), defoliated trees did exhibit some reduction in diameter. Trees defoliated above 50 percent had the greatest growth loss (23-26 percent), but diameter growth for trees defoliated at 25 percent did not decrease (fig. 2).

For the 2000 growing season, most height gain occurred from May to August (fig. 3), with slower gains thereafter. This pattern was consistent for defoliated and control trees. Control trees gained approximately 5.3 feet in height. Trees defoliated at 25 percent gained 4.0 feet, whereas trees defoliated above 50 percent gained only 3.5 to 3.6 feet on average. Diameter growth increased steadily over 2000, with control trees gaining 0.77 inches. Trees defoliated at 25 percent gained 0.69 inches, whereas trees defoliated above 50 percent gained only 0.57 to 0.59 inches (fig. 4).

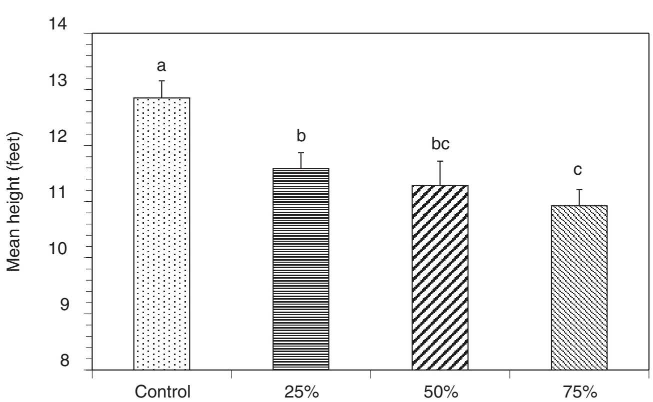

Figure 1—Mean height growth compared across artificially defoliated and control trees.

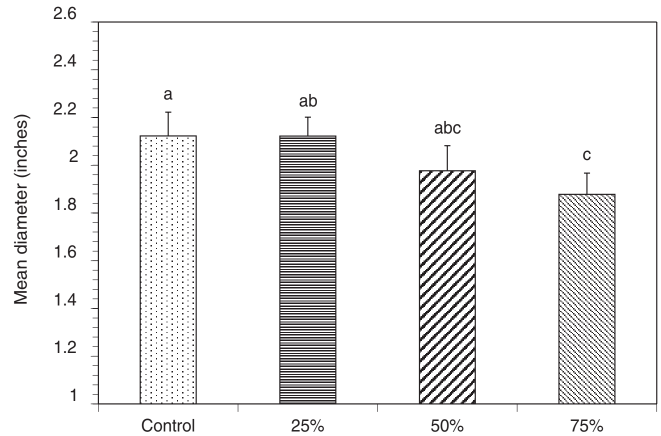

Figure 2—Mean diameter growth compared across artificially defoliated and control trees.

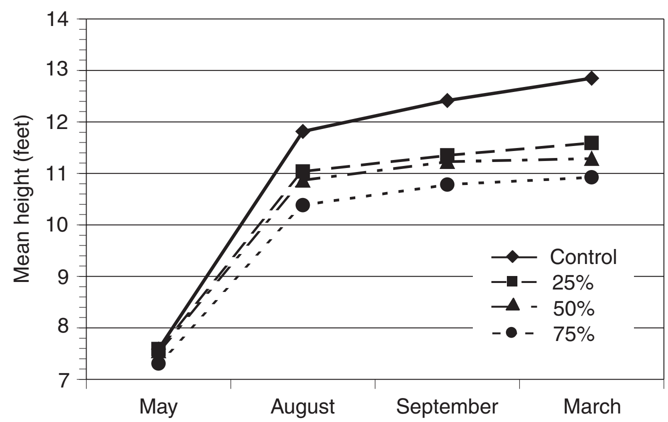

Figure 3—Mean height growth over time for artificially defoliated and control trees.

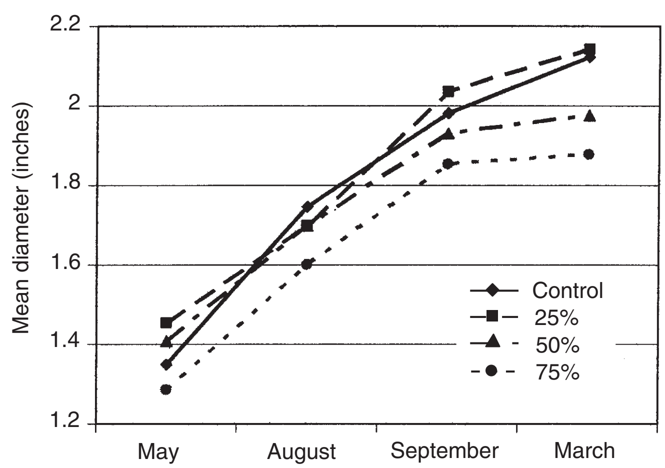

Figure 4—Mean diameter growth over time for artificially defoliated and control trees.

DISCUSSION

Our results indicate that increasing severity of defoliation can lead to correspondingly significant decreases in growth. This concurs with earlier studies examining the effects of artificial defoliation on *Populus* by Bassman and others (1982) and Reichenbacker and others (1996). In our study, the most pronounced reductions occurred for height. Defoliated trees, on average, lost 24 to 31 percent in height growth when compared to undefoliated trees. Reductions were noticeable across the entire range of defoliation treatments, from light to severe. No significant decreases in diameter growth were observed between defoliated and undefoliated trees.

Loss in height gain is, in part, attributable to damage inflicted to terminals during the process of artificial defoliation. Our defoliation technique was intended to mimic natural CLB defoliation. Although mechanically different, damaged terminals are a typical end result of CLB feeding activity, particularly during heavy infestations. Consequently, our results should reflect real impacts that could be anticipated from comparable levels of CLB defoliation.

Although based upon simulated defoliation, it appears that even relatively low level CLB defoliation (25 percent) could have a marked impact upon biomass accumulation in *Populus* plantations. However, what level of defoliation is tolerable will most likely be dictated by the economics of managing a CLB infestation. Some questions that need to be considered are: Is the potential reduction in growth loss so great that pesticide application is required? Is it economically feasible to leave the plantation alone? Based on these results, it would seem important for managers of *Populus* plantations to treat CLB infestations as soon as they are noticed early in the season.

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LITERATURE CITED

Bassman, J.; Myers, W.; Dickman, D.; Wilson, L. 1982. Effects of simulated insect damage on early growth of nursery-grown hybrid poplars in northern Wisconsin. Canadian Journal of Forest Research. 12: 1-9.

Caldbeck, E.S.; McNabb, H.S., Jr.; Hart, E.R. 1978. Poplar clonal preferences of the cottonwood leaf beetle. Journal of Economic Entomology. 71: 518-520.

Fang, Y.; Hart, E.R. 2000. Effect of cottonwood leaf beetle (Coleoptera: Chrysomelidae) larval population levels on *Populus* terminal damage. Environmental Entomology. 29(1): 43-48.

Harrell, M.O.; Benjamin, D.M.; Berbee, J.G.; Burkot, T.R. 1982. Consumption and utilization of leaf tissue of tissue cultured *Populus x Euramericana* by the cottonwood leaf beetle, *Chrysomela scripta* (Coleoptera: Chrysomelidae). Canadian Entomologist. 114(8): 743-749.

Reichenbacker, R.R.; Schultz, R.C.; Hart, E.R. 1996. Impact of artificial defoliation of *Populus* growth, biomass production, and total non-structural carbohydrate concentration. Environmental Entomology. 25: 632-642.

SAS Institute, Inc. 1998. Statview reference, version 5. Cary, NC: SAS Institute. 528 p.