GENOTYPE X FERTILITY INTERACTIONS IN SEEDLING SWEETGUM

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Abstract—Genotype x fertility interactions may affect the suitability of sweetgum (*Liquidambar styraciflua* L.) for specific sites or the efficiency of nutrient use. To gain a better understanding of these interactions, 2-year-old sweetgum seedlings from two half-sib families were tested for growth response to N (0 and 100 kg/ha equivalent) and P (0 and 50 kg/ha equivalent) for one season in an outdoor pot study. Sweetgum seedlings responded rapidly to N and P treatments, in both stem and crown size. Nitrogen, P and family genotype explained 37, 21 and 10 percent of the response in basal diameter growth, respectively. The data suggest that screening sweetgum families for nutrient use efficiency may be worthwhile, and that balanced N and P applications are important for promoting seedling growth.

INTRODUCTION

Sweetgum (*Liquidambar styraciflua* L.) is an important hardwood timber species in the U.S. south (Kormanik 1990), and many hardwood plantations established for short-rotation pulpwood production in this region are sweetgum (Robison and others 1998). Developing genetically improved hardwoods for fast growth and high quality, and formulating site-specific and fertilization guidelines for hardwood plantation establishment have been rated as priorities for hardwood research in North America (Meyer 1996). A better understanding of the genetic variation in sweetgum growth response to silvicultural practices, such as fertilization, can improve the efficiency of timber production by best utilizing genetically improved planting stock.

Sweetgum families have been shown to respond differentially to N, but not to P applications (Nelson and Switzer 1990). Nelson and Switzer (1990) found significant family x fertility interactions for nitrogen. In three of the 4 families they tested, maximum growth response was at 200 kg N/ha, while the other half-sib family had its maximum growth response at 400 kg N/ha. Other studies in Mississippi by the same research group have reported various sweetgum genetic effects related to nutrition (Nelson and others 1995a, Nelson and Switzer 1992, Nelson and Switzer 1990, Nelson and others 1995b).

The current study examines genotype x fertility interactions in seedling sweetgum, using two half-sib families selected from among the circa 350 families in the NC State University - Hardwood Research Cooperative (NC State-HRC) genetic improvement program. These two families had in earlier work demonstrated substantially different responses to high and low fertility levels (Birks and Robison 2000). The aim of this work was to develop an understanding of the proportion of growth response attributable to genotype x fertility interactions. If such interactions are significant, then protocols for use in genetic selection, and site and fertilization decision-making, can be devised to best utilize specific genotypes. In the current study we specifically examine N and P fertility effects.

MATERIALS AND METHODS

This experiment was conducted in pots (22 cm diameter by 25 cm deep) out-of-doors at the Horticulture Field Laboratory of North Carolina State University in Raleigh, NC. Seed from two half-sib sweetgum families in the NC State-HRC program (F10022 and F10023), collected from a seed production area in St. George, SC (SC Forestry Commission land) were used in this work. Stratified seed were sown, two per pot from the same family, on 22 July 1999, into pots containing peat:vermiculite:field soil in a 6:3:1 (volume) ratio. The field soil (Congoree silt loam) was collected from an area with naturally occurring sweetgum in Raleigh, NC. After germination, all pots received a one-time application of 1.45 g of Osmocote™ slow-release fertilizer (14-14-14) to ensure adequate nutrition for healthy seedling development in the first growing season. Seedlings were thinned to one per pot in September 1999, to leave similarly sized plants among pots. Seedlings were overwintered outdoors and experimental treatments applied in the second growing season. Pots were widely spaced throughout the experiment to eliminate shading.

On 6 July 2000, four treatments were applied to both families, 1) no N or P (control), 2) no N and 50 kg/ha equivalent P, 3) 100 kg/ha equivalent N and no P, and 4) 100 kg/ha equivalent N and 50 kg/ha equivalent P. There were three pots for each family within each treatment. Fertilizers were applied as granular NH_4NO_3 and triple superphosphate. Pots received daily overhead irrigation.

Initial seedling size (ground-line basal diameter, total height, unit leaf weight, unit leaf area, and specific leaf area

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Citation for proceedings: Outcalt, Kenneth W., ed. 2002. Proceedings of the eleventh biennial southern silvicultural research conference. Gen. Tech. Rep. SRS–48. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 622 p.

[SLA]) was measured on 23 June 2000. Leaf weight and area (then used to calculate SLA) were estimated by sampling five mid-crown fully expanded leaves from every tree. Final seedling size (same parameters as above, plus crown dimensions [height and width]) was measured on 7 September. Leaf samples were dried at 65 °C and weighed. Crown volume was calculated as a conoid from height and width measurements.

Statistical analyses were performed with SAS (SAS Institute, Cary, NC, Version 7.01).

RESULTS AND DISCUSSION

All initial seedling size measurements were compared by ANOVA among treatments. None differed significantly at $P < 0.05$ among treatment or family effects, or with any interactions. A few of the initial size measurements differed among treatments and families at $P < 0.10$. These were leaf weight among N, P and family factors, SLA by P levels, and height by family.

At the time of final measurements (two months after the treatments were applied) SLA was significantly ($P < 0.01$) affected by N, P, and an N x P interaction, but not by family (figure 1a). Without N addition seedling sweetgum SLA did not respond to P.

This response of SLA to N was consistent with those reported by Nelson and others (1995b). They reported SLA effects only three years after N application. In the current study we measured SLA changes in two months, and found a significant P effect. These changes in SLA suggest that when N and P are applied in correct proportion, seedlings will have greater photosynthetically active areas, and may grow more rapidly (Walters and Reich 1996). This may be of immediate relevance in sweetgum nurseries, and of longer-term importance in crown closure (and its effect on weeds) and productivity in field plantings. In herbaceous species it has been reported that nutrient additions do not impact SLA when photosynthetically active radiation is not limiting (Meziane and Shipley 1999), however our data indicates that sweetgum SLA was responsive to added nutrients under full light.

Initial and final basal diameters were significantly correlated, however initial and final heights were not. Basal diameter was affected by the experimental factors; family ($P < 0.01$), N ($P < 0.1$), and P ($P < 0.05$) (figure 1b). Family F10023 consistently had greater basal diameter than F10022, nitrogen addition was marginally significant at each P level, and P addition was significant regardless of the rate of N application. There were no interactions among these three factors with respect to diameter.

Seedling height was significantly affected by family ($P < 0.05$) and N application ($P < 0.05$) (figure 1c). However, in contrast to the findings for basal diameter growth, family F10022 was consistently taller than family F10023. No interactions with respect to height were found. In the current study the two month (current) growth increment was significant, corroborating earlier findings of rapid sweetgum response to resource availability (Hopper and others 1992, Lockaby and others 1997, Nelson and Switzer 1990, 1992, Nelson and others 1995a).

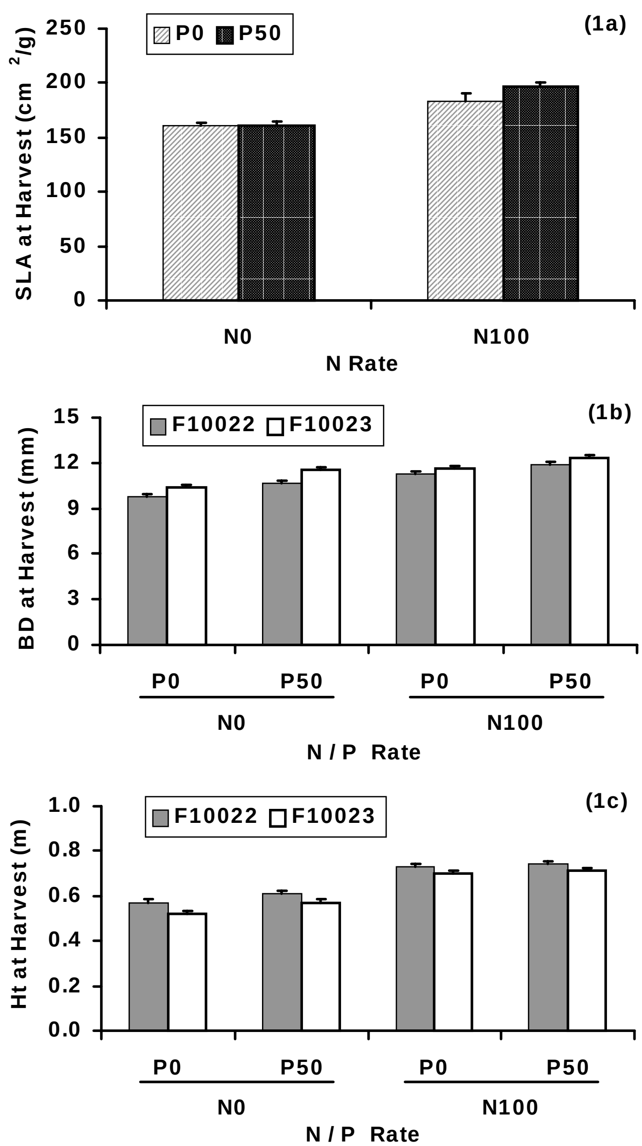

Figure 1—Mean + SE (n = 4) response of 2-year-old sweetgum to N and P application, and family (F10022 and F10023), by specific leaf area (SLA), seedling basal diameter (BD) and height (Ht), two months after treatment. figure 1a shows the interaction between N and P ($P < 0.05$) treatments on SLA when family was not significant. In figure 1b, N ($P < 0.10$), P ($P < .0.05$) and family ($P < 0.05$) were significant; and in figure 1c, N and family ($P < 0.05$) were significant.

Physiological responses to nutrient additions often appear first in foliar characteristics and crown expansion. Crown width in the current study was significantly correlated with initial seedling height ($P < 0.05$), and was affected by N ($P < 0.01$) and P ($P < 0.01$) additions (figure 2a). Differences in crown width between the families were not significant, nor were there any significant treatment

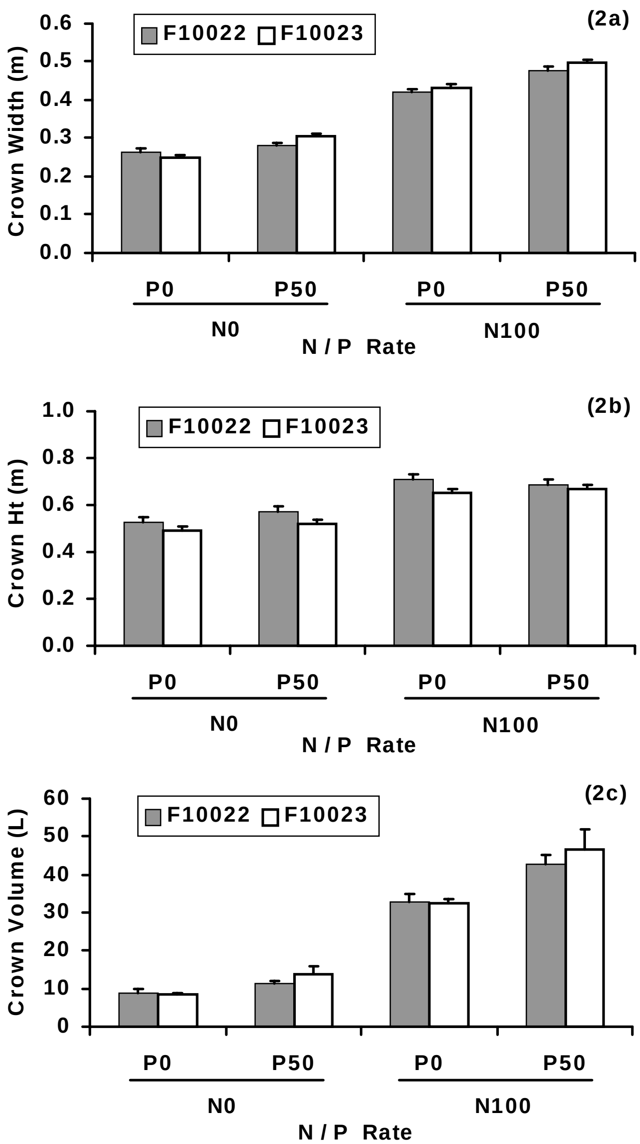

Figure 2—Mean + SE (n = 4) response of 2-year-old sweetgum to N and P application, and family (F10022 and F10023), by crown width, crown height and crown volume, two months after treatment. In figure 2a, N and P were significant ($P < 0.05$); in figure 2b, N and family were significant ($P < 0.05$); and in figure 2c, N and P were significant ($P < 0.05$).

interactions. Crown height was significantly correlated with initial SLA ($P < 0.05$), and was affected by family ($P < 0.05$) and N ($P < 0.01$) application (figure 2b). For crown height (similar to total height, figure 1c), family 10022 was greater than family 10023. When crown width and height were integrated into crown volume, family differences were not significant (figure 2c), although N and P additions increased crown volume. No interaction between N and P was found.

The significant effects of the N and P treatments on crown volume (Fig 2c) and SLA (Fig 1a) may be responsible, through their relationship with photosynthetic area, for the seedling growth responses found. With respect to basal diameter, N, P and family explained 37, 21 and 10 percent of the growth response, respectively.

CONCLUSIONS

N and P application affected the growth rate of two-year-old sweetgum seedlings, two months after treatment. Two half-sib families responded to the N and P treatments differently, indicating significant genotype x fertility variation in sweetgum. Thus it may be possible to select genotypes that are more efficient in nutrient use. Results suggest the need to balance N and P applications to seedling sweetgum, and that N generally limits the response to P.

ACKNOWLEDGMENTS

The authors thank Peter Birks, David Gadd, Jim Bridges, Jamie Schuler and other staff of the NC State-HRC for assistance with this project. This work was supported by the industrial and state agency members of the NC State-HRC.

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