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Effects of Herbicide Application on Foliar Morphology and Nutrient Concentrations in Mid-Rotation Pine Plantations

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Abstract

Application of herbicide to reduce competing brush and hardwood species is a common silvicultural activity in young loblolly pine (*Pinus taeda*) stands. A reduction in competition generally increases the amount of available resources to the loblolly pine crop trees thereby increasing foliage biomass, fascicle dimensions, and foliar nutrient concentrations. To what extent herbicide application and competition control alters these foliar characteristics in mid-rotation stands has rarely been reported. The purpose of this paper is to evaluate whether the application of herbicide alters the morphology, mass, and/or nitrogen concentration of mid-rotation loblolly pine foliage. We aerially applied an imazapyr herbicide to 6 study plots within each of four mid-rotation stands in Louisiana and Arkansas. Another 6 plots in each stand were untreated and served as a control Average fascicle length, fascicle mass, and foliage nitrogen concentrations in the herbicided-treated plots did not significantly differ from that in the control plots. However, foliage concentrations and fascicle size one year after herbicide application were greatest in plots with the greatest competing vegetation mortality.

Introduction

Silvicultural activities that increase the amount of leaf area and foliage biomass enhance photosynthetic activity and thus result in increased stem growth and timber production of crop trees (Will et al., 2002). Silvicultural practices such as thinning and fertilization alter foliage morphology as well as leaf area and mass (Velazques-Martinez et al., 1992; Yang, 1998) by increasing available resources such as light, water, and/or nutrients. Herbicides are extensively used to control brush and hardwood competition in loblolly pine (*Pinus taeda*) stands (Scultz, 1997). Competition control can increase site resources available for crop trees which would otherwise be utilized by competing vegetation. In young pine plantations, competition control increases soil water thereby reducing the water stress of crop trees (Perry et al., 1994), potentially increases nitrogen availability (Nusser and Wentworth, 1987), and increases the amount of light available to recently established crop trees (Morris et al., 1993). As a result, loblolly pine foliage morphology, nutrient concentrations, mass, and area can be altered (Zutter et al., 1999) by controlling competition in early stages of stand development. To what degree competition control in older, mid-rotation loblolly pine stands modifies these foliar attributes has not been documented. As part of a study investigating the effect of competition control and fertilization on productivity of mid-rotation pine stands, we monitored the response of pine foliage (physical attributes and nutrient concentrations) to the application of herbicide and the resulting reductions in hardwood and brush competition.

Materials and Methods

The study was established in 4 loblolly pine stands within the Gulf Coastal Plain of Arkansas and Louisiana, one to one and half years following an initial thinning operation. Two stands (Crossroads and Marion) are located in Union Parrish, Louisiana. The other stands (South Crossett and West Crossett) are located in Ashley County, Arkansas. Soils in all stands were either Alfisols or Ultisols. Table 1 contains soil and stand characteristics for each study site.

Loblolly pine is the most dominant species in the stands with loblolly and shortleaf pine (present only in one stand) accounting for approximately 91% of the total basal prior to treatment application. Sweetgum, red maple, blackgum, and water oak represented 69% of the basal area of the hardwood and brush stems that had diameters at breast heights (dbh) greater than or equal to 2.54 cm. These hardwood species accounted for 62% of the hardwood and brush stems prior to treatment application. The Louisiana stands had lower pine and higher hardwood densities than the stands in Arkansas. The total basal area ranged from a low of 15.2 m^2 ha^{-1} at Marion to 17.2 m^2 ha^{-1} at West Crossett study site (Table 1). The proportion of hardwood and brush to pine basal area ranged from approximately 6.5% to 20.1%. Thus the stands comprised a wide range of stand densities as well as diversity in stand composition.

Table 1. Soil and stand characteristics for each site at the time of study initiation

Site Yr.	Age m^2ha^{-1}	Pine BA[1] BAm^2ha^{-1}	Non-pine Index[2]	Site Height m	Mean Pine Family	Dominant Soil Family
Crossroads	17	16.0	3.2	20.1	13.1	Plinthic Paleudults and Typic Paleudults
Marion	17	12.9	2.3	9.2	13.6	Aquic Paleudults
South Crossett	22	16.5	0.7	18.3	13.1	Aquic Fraglossudalfs and Oxyaquic Fraglossudalfs
West Crossett	17	26.8	1.7	18.9	12.1	Oxyaquic Fraglossudalfs

[1]Trees >2.54 cm dbh
[2]Estimated with base age 25

A total of 12 plots between 0.036 and 0.097 ha in size was established in each stand during the fall of 2001 or 2002. The stands serve as blocks in the experimental design. In September or October of the year of plot establishment, imazapyr herbicide was operationally applied to 6 of the 12 plots. The application rate was 1.162 l of herbicide and 0.234 l of surfactant per hectare. The remaining 6 plots in a stand were not herbicided and were retained as a control.

Twenty five first-flush, current-year-fascicles were collected annually from 5 dominant or codominant loblolly pine trees in each plot during January. The initial collection occurred 15–16 months after herbicide application. The same 5 trees from each plot were sampled each year. We used a shotgun to collect a primary lateral branch from the upper one third portion of the live crown. After branch collection, 25 fascicles were removed from the lateral branch section using latex gloves. Only whole, healthy fascicles typical of the crown were collected. We then removed dirt and contaminants from the fascicles if necessary. The fascicles from each tree on a plot were composited to make a total of 125 fascicles from each plot. The fascicles were then stored at 4°C until foliage could be dried. Within one week of collection the foliage was dried at 65-70°C for 24–28 hr. All 125 fascicles from a plot were massed to the nearest 0.01 gram after drying. In addition we measured the lengths of 10 randomly selected fascicles from each plot composite.

All fascicles collected on a plot for a given sampling period were then ground to pass through a 0.5 mm screen for chemical analysis. Nitrogen concentration was determined by combustion using an Elementar CN analyzer. We used a generalized randomized block design ANOVA to analyze fascicle length, fascicle mass, and nitrogen concentration as a random effect with sites as blocks. We analyzed data obtained for two consecutive years following herbicide application. We also used Pearson correlations coefficients to investigate the relationship of fascicle length, fascicle mass and foliage nitrogen concentration with competitor mortality.

Results

***Mortality*.**–At the end of the first growing season following herbicide application hardwood and brush mortality in the herbicide-treated plots was 49.9, 56.7, 23.8, and 32.7 % of the initial hardwood and brush basal area for the Crossroads, Marion, South Crossett, and West Crossett stands, respectively. The greatest mortality occurred in the Louisiana sites, which had the highest hardwood basal area and stem density. Prior to imazapyr application, hardwood and brush comprised a greater proportion of the total basal area at the Louisiana sites (15-17%) than the Arkansas sites (4-6%).

***Fascicle Length*.**–Mean fascicle length in the first year following the herbicide application was higher in herbicide plots than the control plots at 3 of the 4 stands (Table 2). In the second year following herbicide application, mean fascicle length was higher in the herbicide plots than the control plots in only 2 stands. The ANOVA tests did not indicate that differences in fascicle length were significant at $P = 0.05$ for either year (first year $P = 0.10$; second year $P = 0.45$). The variation in fascicle length during the first year following herbicide application was consistently greater in the herbicide-treated plots than the control plots. The coefficient of variation for the control and herbicide-treated plots in the first year was 4.0% and 7.4%, respectively. Variances were not significantly different

Table 2. The mean and coefficient of variation (CV) for fascicle length, fascicle mass, and foliage nitrogen concentration for each site by herbicide treatment one year following herbicide application.

Site	Treatment	Fascicle length		Fascicle mass		Foliage N (%)	
		Mean(cm)	CV(%)	Mean(mg)	CV(%)	Mean	CV
Crossroad	Control	17.4	3.4	151	6.4	1.4	5.6
	Herbicide	18.2	6.7	177	6.7	1.4	7.2
Marion	Control	17.5	3.4	141	8.1	1.3	5.3
	Herbicide	17.4	7.7	144	11.8	1.4	3.3
South Crossett	Control	17.7	4.7	158	9.3	1.2	6.0
	Herbicide	18.2	6.6	159	8.2	1.2	3.2
West Crossett	Control	16.7	2.6	146	10.6	1.2	2.5
	Herbicide	17.1	8.8	135	10.3	1.2	6.5

between the treatments for foliage collected the second year following herbicide application.

Fascicle Mass.–Like fascicle length, fascicle mass in the first year following herbicide application was higher in the herbicide-treated plots than the control plots at three of the four stands (Table 2). The ANOVA indicated that there was no significant difference in the mean fascicle mass between the herbicide and control treatments in either year following herbicide application (first year $P = 0.57$ and second year $P = 0.92$). Similar to fascicle length, there was a consistent difference in the variance of fascicle mass between the herbicide-treated and control plots. The coefficients of variation of fascicle mass in the control and herbicide-treated plots were 9.2% and 13.5%, respectively.

Nitrogen Concentration.–Foliar nitrogen concentrations (Table 2) was lowest in the control plots at South Crossett (mean = 1.20 %) and highest in the herbicide plots at Crossroads site (mean = 1.41 %). Differences in foliage nitrogen concentration between treatments was neither significant the first year ($P = 0.28$) or the second year ($P = 0.32$) following herbicide application.

Correlation Analysis.–Mass, length, and nitrogen concentrations of fascicles in the herbicide-treated plots generally increased with increased hardwood mortality (Figs. 1a and 1b). Hardwood and brush mortality were positively and significantly correlated with fascicle length ($r = 0.28$, $P = 0.054$), fascicle mass ($r = 0.42$, $P = 0.003$), and foliage nitrogen concentration ($r = 0.48$, $P = 0.001$) the first year following herbicide application. Hardwood and brush mortality was not significantly correlated with any of these fascicle characteristics the second year following herbicide application.

Discussion

There was generally no consistent impact of the herbicide treatment on the foliage among the 4 sites. ANOVA tests indicated that differences in fascicle length, fascicle mass, and N concentrations between treatments were not significant for either the first or second year after herbicide application. The lack of response may be related to position of the pine and hardwood/brush competitors within the canopy. Loblolly pine occurs in the mid and upper portion of the canopy while the hardwood/brush occurs primarily in the lower portions of the canopy. Since the foliage samples were collected from the upper third of the loblolly pine crowns , removal of hardwoods and brush which occur in the lower portion of the canopy would have little impact on the light regimes where the foliage samples were collected. In young pine plantations, brush and hardwood competition occurs within the upper portion of the canopy and any reductions in competition increases the amount of light throughout the entire of canopy. This change in light increases fascicular length, fascicle mass as well as photosynthesis throughout the length of a pine's

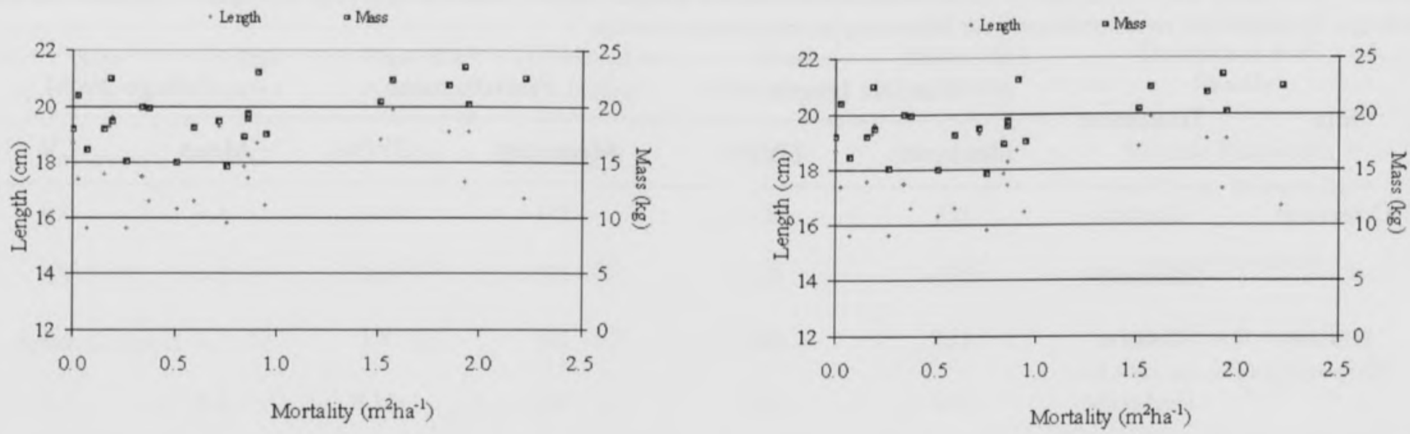

Fig. 1. Hardwood and brush mortality with length and mass (a) and nitrogen concentrations (b) of loblolly pine foliage one year after herbicide application.

crown. Foliar responses in older stands following thinning reflect the fact that tree removal results in crown removal throughout the entire canopy. Thus, removal of these trees increases light intensity to a greater degree than from the removal of midstory and understory competition in mid-rotation stands.

There was also no consistent response of foliar N concentrations to herbicide application. It seems likely that the hardwood and brush competitors did not represent a major sink for N at these sites and thus significantly reduce the amount of N available to the loblolly pine crop trees. In addition, N contained in trees killed by the herbicide needs to mineralize before the N would become available for uptake by the pine trees. This may take several years and would only result in an increase in foliar N concentration after a considerable period of time following herbicide application.

One consistent impact of the herbicide was an increase in the variation of both the fascicle length and mass during the first year following application. The coefficient of variation of these parameters was higher for the herbicide-treated plots than the control plots at each individual site. This may reflect a direct antagonistic impact of the herbicide on the foliage. The fascicles collected the first year following herbicide treatment were set in the bud at the time of the herbicide application. Potentially, variation in densities, sample tree locations, and other plot characteristics may have contributed to the variation in herbicide contact with the buds and thus the impact of herbicide on the emergent foliage.

The significant, positive correlations of first year foliar measurements with hardwood and brush mortality suggest that foliage response increases with the level of competition release. Intuitively we expect that the greater the reduction in competition, the greater the amount of resources available for the remaining crop trees and thus the alteration of foliar characteristics. The lack of significant differences in foliar characteristics between the herbicide-treated and control plots indicated by the ANOVA may reflect the wide range in hardwood densities and mortality among sites. The lack of any significant correlations of mortality and second year characteristics suggests that any changes in resources were either short-lived or that these resources were used by the crop trees to produce more fascicles rather than larger fascicles with higher N concentrations.

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Literature Cited

Morris, LA, SA Moss, and **WS Garbett.** 1993. Competitive interference between selected herbaceous and woody plants and Pinus taeda L. during two growing seasons following planting. Forest Sciences 39:166-187.

Nusser, SM and **TR Wentworth.** 1987. Relationships among first-year loblolly pine seedling performance, vegetation regrowth, environmental conditions and plantation management practices. Pp. 565-75, *In* Proceedings of the 4th Biennial Southern Silvicultural Research Conference, 4-6 Nov. 1986. Atlanta, GA. Dr. R. Phillips, Editor. USDA Forest Service Technical Report SE-42. 598 pp.

Perry, MA, RJ Mitchell, BR Zutter, GR Glover, and **DH Gjerstad.** 1994. Seasonal variation in competitive effect on water stress and pine responses. Canadian Journal of Forest Research. 24:1440-1449.

Scultz, RP. 1997. Loblolly pine: the ecology and culture of lobloly pine (*Pinus taeda* L.). Pp. 8.1-8.36. *In* USDA Forest Service Agrcultural Handbook-713.

Velazquez-Martinez, A, DA Perry, and **TE Bell.** 1992. Response of aboveground biomass increment, growth efficiency, and foliar nutrients to thinning, fertilization, and pruning in young Douglas-fir plantations in the central Oregon Cascades. Canadian Journal of Forest Research 22:1278-1289.

Will, RE, GT Munger, Y Zang, and **BE Borders.** 2002. Effects of annual fertilization and complete competition control on current annual increment, foliar development, and growth efficiency of different aged *Pinus taeda* stands. Canadian Journal of Forest Research 32:1728-1740.

Yang, RC. 1998. Foliage and stand growth responses of semimature lodgepole pine to thinning and fertilization. Canadian Journal of Forest Research. 28:1794-1804.

Zutter, BR, JH Miller, HL Allen, SM Zedaker, MB Edwards, and **RA Newbold.** 1999. Fascicle nutrient and biomass responses of young loblolly pine to control of woody and herbaceous competitors. Canadian Journal of Forest Research 29:917-925.