IMPACT OF WEED CONTROL AND FERTILIZATION ON GROWTH OF FOUR SPECIES OF PINE IN THE VIRGINIA PIEDMONT

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Abstract—During 1999, a mixed stand of Virginia pine and hardwoods in the Piedmont of Virginia was clearcut and site prepared by burning. Three replications, containing strips of loblolly pine, shortleaf pine, Virginia pine, and Eastern white pine, were planted at a 3 m x 1.5 m spacing during February to June, 2000. The strips were subsequently split to accommodate four different silvicultural treatments: (1) check - no treatment; (2) weed control; (3) fertilization; and (4) weed control plus fertilization. Herbicides were applied in 2000 (broadcast Oust®), 2001 (directed spray of Garlon® plus Roundup®), and 2003 (directed spray of Roundup®) to control both herbaceous and woody competition. Fertilizers containing N, P, and K were applied in 2001, N only in 2002. Crop tree survival was highest for loblolly pine, followed by Virginia pine, shortleaf pine and, lastly, Eastern white pine. There was a significant species x silvicultural treatment interaction at this site. Total height after 4 years followed the pattern loblolly pine>Virginia pine=shortleaf pine>white pine. In loblolly pine, weed control and fertilization increased growth compared to the check. In white pine, there was no significant difference between weed control and weed control plus fertilization compared to the check. However, white pines in the fertilized only plots were shortest due to increased hardwood competition that overtopped the pines.

INTRODUCTION

A significant amount of the forest resource in Virginia is in the Piedmont Physiographic Province, which contains about 2.5 million ha of private and industrial commercial timberland (Brown 1986). Almost three-fourths of these forests are comprised of pine-hardwood forest types (Brown 1985, 1986). The timber in many of these stands is poor because of low quality stems and undesirable species (Knight and McClure 1978). Many of the lands owned by nonindustrial private landowners are producing at ≤ 50 percent of their productivity potential (Dubois and others 1990).

Many of the mixed pine-hardwood stands in the Piedmont are converted to pine plantations after clearcutting (McGee 1980, 1982). Plantations account for 17 percent of the forest land in the Southeast (Conner and Hartshell 2002, Guldin and Wigley 1998). The desire to maximize productivity from a given area of forest has necessitated the development of intensive management practices. Modern plantation management has concentrated on increasing forest productivity through tree improvement, vegetation management, and fertilization (Fox and others 2005). The goal is to develop integrated site-specific management regimes that incorporate the potential gains from genetic improvement and silvicultural practices (Stanturf and others 2003). This includes matching planting stock to sites to fully utilize the productive potential of the sites. Selecting the species best adapted to the given conditions is the first step in this process (Pait and others 1991).

The objectives of this study were to investigate the impact of weed control and fertilization on survival and growth of four pine species planted after harvesting mixed oak-pine stands in the Piedmont of Virginia. The four species were: eastern white pine (*Pinus strobus* L.), loblolly pine (*Pinus taeda* L.), shortleaf pine (*Pinus echinata* Mill.), and Virginia pine (*Pinus virginiana* Mill.).

STUDY SITE LOCATION

This study was established at the Reynolds Homestead Forest Resources Research Center (RHFRRC) in Patrick County, VA. The soil is an eroded phase of the Cecil series (fine kaolinitc, thermic Typic Kanhapludult). The soil series is characterized as deep, well-drained, and moderately permeable, formed in residuum of felsic, igneous, and high-grade metamorphic rock on Piedmont uplands (NRCS 2003). Slopes range from 6 to 10 percent. Summer temperatures range from 39 °C to 2 °C with an average of 25 °C. Winter temperatures range from 23 °C to -9 °C with an average of 10 °C. The frost-free period is between mid-April and the end of October. Yearly average rainfall is 49 inches, with a monthly average of 4 inches (Crockett 1972).

Stand quality on these sites prior to harvest was poor. Pre-harvest stand composition was a mixture of white oak (*Quercus alba* L.), red maple (*Acer rubrum* L.*)*, yellow poplar (*Liriodendron tulipifera* L.*)*, chestnut oak (*Q. prinus* L.), scarlet oak (*Q. coccinea* Muenchh.), sourwood [*Oxydendron arboretum* (L.) DC], and Virginia pine.

STUDY DESIGN

This study was established as a Strip-Plot Design (SPD) with two sets of treatments randomized across each other through the whole block, with three blocks (replications). The first set of treatments was the pine species planted: (1) eastern white pine; (2) loblolly pine; (3) Virginia pine; and (4) shortleaf pine. The second set of treatments was the silvicultural treatment: (1) check -no treatment applied after planting; (2) weed control; (3) fertilization; and (4) weed control plus fertilizer combined.

The stand was clearcut in 1999, and between February, 2000, and June, 2000, the 4 pine species were planted in strips 30.4 m wide. These plots were subsequently split to accommodate the different silvicultural treatments that were applied in 15.2-m-wide strips with buffer zones between the different

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Table 1—Timetable of silvicultural treatments applied in the corresponding plots. The plots are located at the RHFRRC near Critz, VA

Date	Treatment
1999	Clear cut
Feb 2000 – June 2000	Planted
2000	Herbicide (Oust®)
20-Jun-01	Fertilizer (50 lbs/plot 10-10-10 + micro)
28-Jun-01	Herbicide (3% Garlon®, 2% Roundup®, 0.5% Induce) directed spray
5-Mar-02	Fertilizer (50 lbs/plot 34-0-0)
15-Sep-03	Herbicide (2% Roundup®)

treatment plots. The trees were planted at a 3 m x 1.5 m distance. The weed control and fertilization treatments applied are summarized in table 1.

Total tree heights of the planted pines were measured at the end of the third growing season in January, 2003. Analysis of Variance and mean separation were performed using proc MIXED and LSMEANS procedures in SAS (SAS 2005) at α=0.10 level of significance.

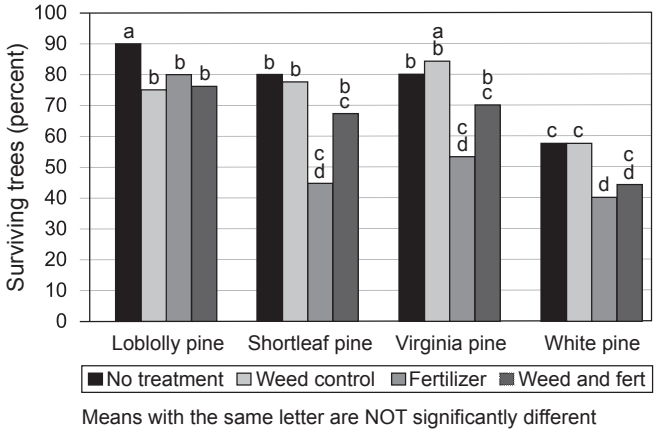
RESULTS AND DISCUSSION

Survival

There was a significant species x treatment interaction effect (p=0.0306) on survival of planted trees (table 2). The check treatment plots in loblolly pine and the weed control treatment in Virginia pine had significantly higher survival rates with more than 90 percent and nearly 85 percent of the trees surviving, respectively (fig. 1). Fertilizer application decreased survival in all species except loblolly pine, suggesting that loblolly pine grows fast enough to compete effectively with the vigorous hardwood competition. Controlling the hardwoods combined with nutrient additions also decreased survival rates compared to the non-fertilization plots. In Eastern white pine, fertilizer application decreased survival with just about 40 percent of the crop trees surviving, suggesting that the initially slow-growing white pine was overtopped by the hardwoods. These findings support the conclusion of Gjerstad and Barber (1987) that hardwoods must be controlled to ensure adequate survival and growth of planted pines in the Piedmont.

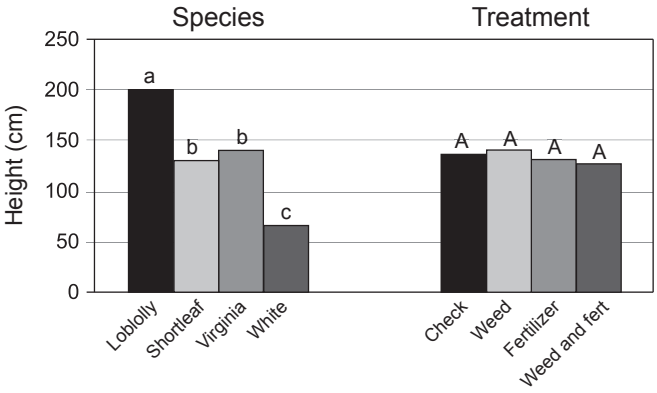
Height Growth

Although weed control plot trees were taller than the rest on average (fig. 2), there was no significant difference in total tree height between the different silvicultural treatments (table 3). The combined weed control and fertilization plots had the shortest average tree height among the treatments. These findings suggest that hardwood competition control alone has less of an impact on crop tree growth than herbaceous vegetation control. Zutter and others (1994) reported that woody and herbaceous control together have an additive effect on



Means with the same letter are NOT significantly different

Figure 1—-Species x silvicultural treatment interaction effects on crop tree survival three growing seasons after planting. The plots are located at the RHFRRC near Critz, VA.



Means with the same letter are NOT significantly different

Figure 2—Main 'species' and 'silvicultural treatment' effects on total tree height three growing seasons after planting. The plots are located at the RHFRRC near Critz, VA.

Table 2—Analysis of Variance (ANOVA) table for the variable 'survival'. The plots are located at the RHFRRC near Critz, VA

Source of variation	Degrees of freedom	Sums of squares (SSQ)	Mean square (MS)	F	P-value
Blocks (Bl)	2	0.01247	0.00623		
Treatment (Trt)	3	0.67016	0.22339	6.13	0.0294
Bl*Trt	6	0.21852	0.03642		
Species (Sps)	3	1.15868	0.38623	8.2	0.0152
Bl*Sps	6	0.28265	0.04711		
Trt*Sps	9	0.31699	0.03522	2.79	0.0306
Error	18	0.22732	0.01263		
Total	47	2.88679			

Table 3—Analysis of Variance (ANOVA) table for the variable 'tree height'. The plots are located at the RHFRRC near Critz, VA

Source of variation	Degrees of freedom	Sums of squares (SSQ)	Mean square (MS)	F	P-value
Blocks (Bl)	2	195.167	97.583		
Treatment (Trt)	3	1,340.420	446.806	0.49	0.7045
Bl*Trt	6	5,518.830	919.806		
Species (Sps)	3	107,654.000	35,885.000	139.77	<0.0001
Bl*Sps	6	1,540.500	256.750		
Trt*Sps	9	1,481.250	164.583	1.04	0.4498
Error	18	2,857.500	158.750		
Total	47	120,588.000			

loblolly pine growth. Groninger and others (1994) found that relative size of pine was dependent on stand composition, density, and amount of herbaceous cover present. Also, fertilization did not enhance pine growth through age 3. This could be due to the lower nutrient requirements of the crop trees at early ages and the increased available nutrients after harvesting due to the Assart effect.

There were significant differences among the four different species of pine planted (table 3). Loblolly pine trees were significantly taller than the other species, averaging about 2 m tall (fig. 2). Eastern white pines were significantly shorter than the other species, averaging about 0.6 m in height. Total tree heights for shortleaf pine and Virginia pine did not differ significantly from each other, with an average height of about 1.3 m and 1.4 m, respectively. These differences can be explained with the species-specific ecological growth patterns, namely the slower initial growth of Eastern white pine, the faster non-determinant growth of shortleaf and Virginia pine, and the vigorous initial growth of loblolly pine.

SUMMARY

Loblolly pine had both the greatest survival and growth through the third growing season after planting, and Eastern white pine had lowest survival and least growth. Virginia pine and shortleaf pine both had intermediate survival and growth compared to the other species with a slight dominance of Virginia pine trees. Weed control was the most beneficial treatment, increasing survival through age 3. Fertilization did not increase growth through age 3 and negatively impacted survival of the planted crop trees.

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