BACKGROUND INFORMATION AND RESEARCH PROBLEM

Nitrogen and phosphorus (P) inorganic fertilizers are commonly applied to loblolly pine stands in the southern United States to increase wood and fiber production. Fertilization of newly established plantations accounts for approximately 20% of the 1.3 million acres of southern pine fertilized annually (Dickens et al., 2003) in the United States. It is expected that the area of pine plantations in Arkansas will increase from 800,000 to 1,600,000 acres by 2040 (Prestemon and Abt, 2002) and thus increase the number of acres and sites that need to be fertilized at or soon after plantation establishment. Currently there are no well established P-fertilizer recommendations for young loblolly pine plantations based on Mehlich-3 extractable P. This lack of data could limit the ability of land managers to maximize the growth of these young plantations.

Nutrient deficiencies of loblolly pine stands are almost exclusively ameliorated with inorganic fertilizers. Poultry litter, which is commonly used in Arkansas to increase forage production, has also been shown to increase yields of crops such as cotton (Nyakatawa et al., 2000; Mozaffari et al., 2005a) and wheat (Mozaffari et al., 2005b). Few studies have evaluated whether poultry litter additions can increase loblolly pine growth. Given that Arkansas produces more than 1.2 million tons of poultry litter annually (Reiter et al., 2004), the application of poultry litter to pine plantations could be an economically attractive method of increasing timber yields. Consequently, this study will provide landowners and forest managers with information to evaluate the potential for increasing pine production through the addition of common inorganic fertilizers and/or poultry litter. The specific objectives of this study are to quantify the effects of different rates of N and P additions on early loblolly pine growth in soils with inherently different levels of soil-P availability, to determine if soil P guidelines developed in other areas of the southern U.S. provide accurate fertilizer recommendations for soils commonly planted to loblolly pine in Arkansas, and to compare loblolly pine growth responses from the addition of N and P as pelleted poultry litter to those obtained with additions of inorganic fertilizer.

PROCEDURES

This study is being conducted at five locations in Arkansas. Research sites were located at the Pine Tree Branch Station (PTBS) in Colt, Ark., the Livestock and Forestry Branch Station (LFBS) near Batesville, Ark., the Southwest Research and Extension Center (SWREC) in Hope, Ark., and two sites on lands owned by Plum Creek Timber Co. (PCC 1 and PCC 2) near Monticello, Ark. Soils at the five sites represent a wide range of textures and soil P availabilities. Each study site consisted of a 1- to 2-year old loblolly pine plantation at the time of plot establishment.

Three replicate plots of each of five treatments were established during January or February at the PTBS in 2005, SWREC in 2006, PCC1 in 2007 and PCC2 in 2007. At LFBS, plots will be established in 2008. The plots at the PTBS and SWREC were established prior to those at PCC1, PCC2, and LFBS as part of a companion study. Plots were approximately 0.20 to 0.25 acres in size. Treatments include three primary nutrient amendments: 1) diammonium phosphate (DAP) + Urea, 2) pelleted poultry litter, and 3) a control without any nutrient amendment. Two separate application levels of pelleted poultry litter and DAP+Urea were utilized to provide two levels of N and P (43 lb N/acre + 57 lb P/acre; 86 lb N/acre + 114 lb P/acre) for a total of five treatments. The application levels of P were based on the general range of recommendations for loblolly pine plantation establishment in the southern United States. Application levels of N assumed pelleted poultry litter has an analysis of 3-4-3 to provide the two levels of P amendment. However, nutrient content of the pelleted litter to be applied at each site was analytically quantified to make site-specific adjustments to litter and supplemental urea application rates. Fertilizer was applied between February and March during 2005 at the PTBS, 2006 at the SWREC, 2007 at the PCC1, and 2007 at the PCC2 sites. Treatments will be applied at the LFBS site in February or March of 2008.

Basal diameter and height of approximately 30 trees located within a central portion of each plot were measured prior to nutrient amendment and annually each dormant season following amendment. At the end of the study (four years after treatment application) diameter at breast height will be measured and used with tree height to determine volume growth response. First-flush, current-year foliage is collected during January the first two years following nutrient amendment.
results from five trees in each plot to assess nutrient deficiencies and nutrient responses to each treatment. Foliage N concentrations were determined using an Elementar Vario Max CN combustion analyzer. Foliage P, K, Ca, Mg, and S concentrations were determined by inductively coupled plasma analysis after perchloric acid digestion.

Mineral soil was collected from each plot to a depth of 6 inches at each site during the dormant season prior to treatment application and annually for two years following treatment application. A total of three subsamples from each plot was analyzed following each collection period. Soils were analyzed for P, K, Ca, Mg, S, and B following the Mehlich-3 (1:10 soil:solution ratio) extraction procedure. Soil samples were analyzed for prior to treatment application were also analyzed for P using Bray-Kurtz P-1 and Mehlich-1 extraction methods. Soil C and N were determined with an Elementar Vario Max CN combustion analyzer.

The experimental design for the study is a randomized complete block with subsampling. Each site is a block and each treatment replicate is a subsample. Differences among treatments were or will be determined using analysis of variance. If the analysis of variance determines that differences are significant, a Tukey’s HSD means separation test will be used to make paired treatment comparisons. All tests will be performed at \( \alpha = 0.05 \).

RESULTS AND DISCUSSION

Currently research plots have been established at four of the five sites. The plantation at the LFBS was planted during February 2007 and plots will be established in 2008. Taxonomic classification and surface textures for the dominant soils at each of the five research sites are presented in Table 1. Initial soil sampling was done prior to plot establishment to evaluate the variability in P concentrations among sites. Average soil-test P was 23, 9, 7, 5, and 3 ppm for the PTBS, LFBS, SWREC, PCC1, and PCC2 sites, respectively. These soils provide a wide range of P availability as well as characteristics to assess loblolly pine growth responses to nutrient additions.

To date, two-year growth responses and one-year growth responses have been summarized for the PTBS and SWREC sites, respectively (Table 2). Nutrient amendments did not significantly increase either basal diameter or height at either of the two sites. The failure of poultry litter and inorganic fertilizer to increase tree growth at the PTBS site is not surprising given the high levels of soil-test P. In addition, foliar concentrations of N and P in the control plots averaged 1.72 and 0.14%, respectively, well above critical concentrations (1.20 and 0.12%) summarized by Ngono and Fischer (2001) for loblolly pine. Thus, it is unlikely that N and P are deficient and limiting loblolly pine growth at PTBS site.

Growth rates at the SWREC were also not affected by nutrient additions. The low growth rates and lack of nutrient responses at the SWREC site may have been related to drought conditions at this site. Precipitation from December 2005, just prior to planting, through November 2006 was 18.02 inches below normal. Mortality rates during this year were relatively high (18 to 31%), reflecting the stress from drought, and were not related to any of the treatments. It is likely that any potential growth responses to nutrient additions will occur when precipitation levels are at or near long-term norms.

PRACTICAL APPLICATION

At this time there has not been a significant response to any nutrient amendment. However, only two of the five sites are old enough to show a growth response to fertilizer and poultry litter application. At one of these sites N and P did not appear to be limiting loblolly pine growth and at the other a severe drought may have limited growth responses. Tree responses to fertilization frequently occur over a 2- to 3-year time span. Thus, future measurements will likely provide a better understanding of the impact of these nutrient additions on loblolly pine growth.

ACKNOWLEDGMENTS

Support for this research was provided by the Arkansas Fertilizer Tonnage Fees, Weyerhaeuser Co., USDA Agricultural Research Services, and Plum Creek Timber Company. The authors also thank the staff of the Pine Tree Branch Station, Southwest Research and Extension Center, Livestock and Forestry Branch Station, and University of Arkansas Soil Testing and Research Laboratory in Marianna for assistance in field work and laboratory analysis.

LITERATURE CITED


Table 1. Classification and surface soil texture for dominant soils at five research site locations.

<table>
<thead>
<tr>
<th>Site</th>
<th>Soil series</th>
<th>Classification</th>
<th>Surface texture</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTBS</td>
<td>Arkbutla</td>
<td>Fine-silty, mixed, active, acid, thermic Fluvenitc Endoaquepts</td>
<td>Silt loam</td>
</tr>
<tr>
<td></td>
<td>Calloway</td>
<td>Fine-silty, mixed, active, thermic Aquic Fraglossudalfs</td>
<td>Silty clay loam</td>
</tr>
<tr>
<td></td>
<td>Longing</td>
<td>Fine-silty, mixed, active, thermic Oxyaquic Fragiudalfs</td>
<td>Silt loam</td>
</tr>
<tr>
<td>LFBS</td>
<td>Noark</td>
<td>Clayey-skeletal, mixed, semiactive, mesic Typic Paleudults</td>
<td>Very gravelly silt loam</td>
</tr>
<tr>
<td>SREC</td>
<td>Sacul</td>
<td>Fine, mixed, active, thermic Aquic Haplundults</td>
<td>Very fine sandy loam, Clay</td>
</tr>
<tr>
<td></td>
<td>Sawyer</td>
<td>Fine-silty, siliceous, semiactive, thermic Aquic Paleudults</td>
<td>Silt loam, Silty clay loam</td>
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<tr>
<td>PCC1</td>
<td>Amy</td>
<td>Fine-silty, siliceous, semiactive, thermic Typic Endoaquults</td>
<td>Silt loam</td>
</tr>
<tr>
<td>PCC2</td>
<td>Guyton</td>
<td>Fine-silty, siliceous, active, thermic Typic Glossaqualfs</td>
<td>Silt loam, Silty clay loam</td>
</tr>
</tbody>
</table>

Table 2. Loblolly pine average annual basal diameter and height growth response to inorganic and poultry litter additions.

<table>
<thead>
<tr>
<th>Nutrient source</th>
<th>PTBS</th>
<th>SREC</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nutrient source</td>
<td>N rate</td>
<td>P rate</td>
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<tr>
<td>Control</td>
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<td>0</td>
</tr>
<tr>
<td>Poultry litter</td>
<td>43</td>
<td>57</td>
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<tr>
<td>Poultry litter</td>
<td>86</td>
<td>114</td>
</tr>
<tr>
<td>DAP + Urea</td>
<td>43</td>
<td>57</td>
</tr>
<tr>
<td>DAP + Urea</td>
<td>86</td>
<td>114</td>
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