Example of Extended Abstract

Responsiveness of Diverse Families of Loblolly Pine to Fertilization

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Loblolly pine is by far the most important forest tree species in the South, with over 1 billion seedlings planted annually by forest industry and non-industrial private forest landowners (McKeand et al. 2003). Genetic gains from tree improvement programs have been large, since geographic and within-provenance variation for growth and adaptive traits in loblolly pine is very large. General trends in productivity variation are that families from southern and eastern coastal sources grow faster than families from northern, western, and interior sources. Contrasting the response to nutrient stress of two very different provenances of loblolly pine such as from the "Lost Pines" region of Texas and the Atlantic Coastal Plain may give us insight into the adaptive significance of different ecophysiological traits.

Previous work indicates that the Lost Pines Texas (LPT) sources are generally more stable across environments, while productivity of eastern sources depends more on the environment. Eastern sources were very responsive to environmental enhancement, since productivity was high on the better sites, but very low on the droughty sites. In this report, we describe a study designed to assess spatial and temporal variation in response of loblolly pine genotypes to environmental stress. Trees have completed eight growing seasons in the field under two different nutrient regimes, and variation in early growth is described.

MATERIALS AND METHODS

The study site is located in Scotland County, North Carolina adjacent to the U.S. Forest Service / N.C. State University SETRES (Southeast Tree Research and Education Site) study. The soil is very infertile and somewhat excessively drained. The existing 10-year-old loblolly pine stand was carefully removed and large block plots of different family-treatment combinations were established. Open-pollinated families from the North Carolina and South Carolina Coastal Plain and from the "Lost-Pines" area of Texas were included in the study. Five families from each provenance with average or slightly above average breeding values for volume were used. Seeds were sown in containers (164 cc RL Super Cells) in the greenhouse in June 1993, and seedlings were field-planted in November 1993.

To facilitate the application of nutrients, a split-split-plot design was used with the two nutrient treatments as main plots, provenances as sub-plots, and families within provenances as sub-sub-plots. Each family plot consists of 100 measurement trees planted at 1.5m x 2.1m' spacing. Buffer trees, 12m around each treatment plot, were planted at the same spacing to eliminate the influence of one nutrient treatment on another. The study was replicated across 9 blocks (10 blocks were originally established, but one was sacrificed after age 6) for a total of 18,000 measurement trees (9 blocks x 2 nutrient treatments x 2 provenances x 5 families per provenance x 100 trees per family plot). Fertilizer has been applied annually to maintain a balanced supply

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of all nutrients in the fertilized plots. Our goal has been to supply optimal levels of nutrients (including micros) each year to stimulate rapid growth.

All trees were measured annually (except for year 7) for height and starting in year 3 for breast height diameter. Individual tree volumes were calculated, and plot volumes were estimated as the sum of the individual tree volumes and converted to per hectare volumes. Analyses of variance were conducted on a family-plot-mean basis. Means and within family-plot standard deviations and coefficients of variation were calculated for height for each 100-tree family plot. Within family-plot standard deviations and coefficients of variation were also subjected to analyses of variance to determine if sub-sub-plot uniformity varied.

RESULTS AND DISCUSSION

Growth responses to fertilization were very large and significant each year (Figure 1). Height was 21%, 46%, 43%, 43%, 43%, 50%, and 66% greater in the fertilized plots for years one to eight, respectively (Figure 1). Volume differences at age 8 were even more dramatic (Control=49.6 m^3/ha, Fertilized=128.0 m^3/ha), with the fertilized trees having 2.6 times more volume per acre than the controls. Although this is a well-drained site, from the results of the nutrition by irrigation study (SETRES) adjacent to this trial, we know that the primary limit to productivity is nutrition (Albaugh et al. 1998). The huge increase in productivity in the first eight growing seasons is possible since all potential nutrient limitations (i.e. more than just N and P) were ameliorated.

One of the most dramatic effects of the nutrition amendments has been the increase in uniformity within the 100-tree family plots. The average within-plot coefficient of variation for eighth-year height was 20.0% for the control plots and 10.1% for the fertilized plots. The within plot standard deviations for height were also significantly different and were 0.96 m for the control plots and 0.83 m for the taller fertilized plots. While increased uniformity typically results from nutritional amendments on very poor sites, the dramatic differences in uniformity were surprising.

As expected, the five families from the Atlantic Coastal Plain grew faster than the five Lost Pines Texas families (Figure 1). We anticipated that under the harsher environmental conditions in the control plots that the Texas families would perform relatively better. However, the ACP families were superior in both environments (Control: LPT=47.2 m^3/ha, ACP=52.1 m^3/ha, Fertilized: LPT=123.7 m^3/ha, ACP=132.3 m^3/ha,), and the provenance by treatment interactions for height in all eight years were not close to being significant.

The provenance by treatment means for volume per acre at age eight are somewhat indicative of the greater responsiveness to nutritional amendments of the Atlantic Coastal Plain provenance compared to the Lost Pines Texas provenance. Although there was no provenance rank change in the two environments, the difference in the magnitude of the provenance means (greater in the fertilized plots) is similar to previous trials.

Families within provenances also differed for growth traits. The family means at age eight for the ACP families varied from 46.8 m^3/ha to 55.4 m^3/ha in the control plots and from 115.3 m^3/ha to 142.5 m^3/ha in the fertilized plots. The Texas families also differed in the control plots (44.2 m^3/ha to 49.6 m^3/ha) and in the fertilized plots (117.1 m^3/ha to 131.8 m^3/ha). The lack of rank change across the treatments both at the provenance and family level was surprising for height and volume. Given the magnitude of the imposed environmental differences and the young age of the trees, differential performance of the families in the two treatments was expected. This result reinforces the tenet of the stability of open-pollinated families of loblolly pine as well as the better responsiveness of the ACP provenance compared to the Lost Pines provenance.

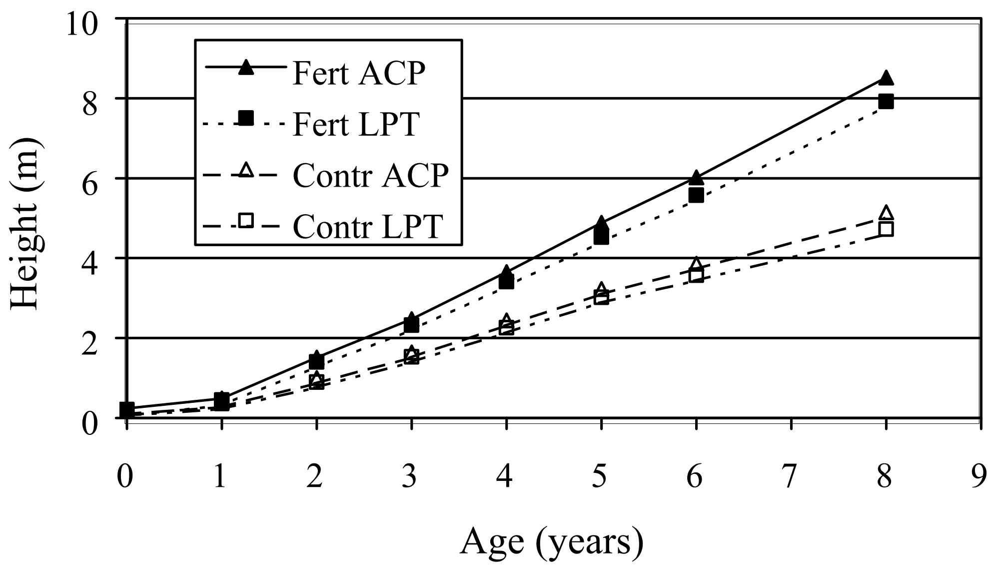

Figure 1. Mean tree heights during the first eight growing seasons in the field for trees from the Lost Pines Texas (LPT) and Atlantic Coastal Plain (ACP) provenances in the fertilized and control plots. Initial height of seedlings (age 0) at planting was measured in 1994.

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