LOBLOLLY PINE GENETICS VERIFICATION TEST FOR PRIVATE NON-INDUSTRIAL LANDOWNERS

Jon E. Barry, Victor L. Ford, and John L. Trauger[1]

Abstract--Forest industry has invested in loblolly pine (*Pinus taeda* L.) genetics to improve growth, branching, and form. Until recently, superior families were destined for industry lands with little of this superior genetic material available for other landowners. Seedlings of superior families are now available to non-industrial private forest (NIPF) landowners at a greater cost than seedlings from first generation selections. The University of Arkansas Division of Agriculture conducts variety and verification trials for agronomic crops and serves as a source of unbiased information on crop genetics. This study applies the same philosophy to loblolly pine genetics by testing growth, survival, form, and branching in southwest Arkansas. The families included Weyerhaeuser first and second-generation select families, four select families and two MCP families from ArborGen, and unrogued and rogued first generation seed orchard mixes from the Arkansas Forestry Commission (AFC). These plantings were established in January 2009 in southwest Arkansas on a fine sandy loam soils. Ten families were planted in 100-tree plots divided among four blocks. Weeds were controlled the first 2 years after planting. Tree height measurements and survival counts have been made annually. Survival after three growing seasons was lowest (61percent) in the AFC unrogued mix and highest (91percent) in an MCP family, averaging 84 percent. This is impressive considering 2011 was a record drought year. Height after three growing seasons was least (2.8 feet) in the Weyerhaeuser first generation family and greatest (4.2 feet) in the Arbor-Gen AG-34 family, averaging 3.4 feet. Branching and form cannot be evaluated until after crown closure.

INTRODUCTION

The variety of loblolly pine (*Pinus taeda* L.) seedlings available to landowners in Arkansas has dramatically increased during the last 10 years. While the vendors of these seedlings have tested the families, no head-to-head verification trials conducted by unbiased entities are known to us. Companies that produce the seedlings claim that tests have shown that they do well in Arkansas, but performance under field conditions in southwest Arkansas is unknown. In keeping with our mission to provide objective science-based information to landowners in Arkansas about the performance of these families, we established a variety trial to compare the performance of 10 commonly available loblolly pine families. These families range from an unrogued woods-run family to an elite MCP family. Unfortunately, one family was available in only limited quantities and had to be excluded from the statistical analysis. We believe this to be the first third-party loblolly pine variety trial to be conducted in Arkansas. The variety trial was established at the University of Arkansas Division of Agriculture's Southwest Research and Extension Center (SWREC) near Hope, AR. This test will be used as a variety trial for loblolly pine and as a demonstration to educate landowners about the seedling families that are available in southern Arkansas.

MATERIALS AND METHODS

The site chosen for the study had been occupied by a pine plantation for approximately 25 years. That stand was harvested in late 2007 and early 2008. Site preparation during 2008 consisted of removing the existing loblolly pine plantation, then windrowing and burning the slash.

Layout

Four thousand bare root 1-0 loblolly pine seedlings representing 10 families (table 1) from three sources were planted in 40 plots of 100 trees each (fig. 1) on the Spencer Tract at SWREC in early March 2009. The seedlings were planted on a 10- by 10-foot spacing by a work crew provided by the Arkansas Department of Corrections. Herbicides were used to control competing vegetation as needed during the first 2 years of the study (table 2). In March and April 2011, hardwood stems and volunteer pine stems were mechanically removed from the plots. Soils underlying the site are predominantly Savannah fine sandy loam on 3 to 8 percent slopes. A small portion of the soils along the north edge of the stand are Sacul fine sandy loam on 3 to 8 percent slopes.

The 40 plots of trees were divided into four blocks of 10 plots each. The intention was that

[1]Extension Forester, Director and Research Associate, respectively, Arkansas Forest Resources Center, Southwest Research and Extension Center, Hope, AR 71801.

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Table 1--Loblolly pine families represented in the variety trial

Producer	Family name	Number of blocks	Source classification
ArborGen	MCP-22M	7	Atlantic coast MCP elite
ArborGen	MCP-29	1	Atlantic coast MCP
ArborGen	34	4	Atlantic coast advanced (2^{d} gen.)
ArborGen	520	4	Arkansas elite
ArborGen	522	4	Arkansas elite
ArborGen	579	4	Arkansas advanced (2^{d} gen.)
AFC	Imp. mix	4	Unknown
AFC	Nat.mix	4	Unknown
Weyerhaeuser	1st gen.	4	Unknown
Weyerhaeuser	2^{d} gen.	4	Unknown

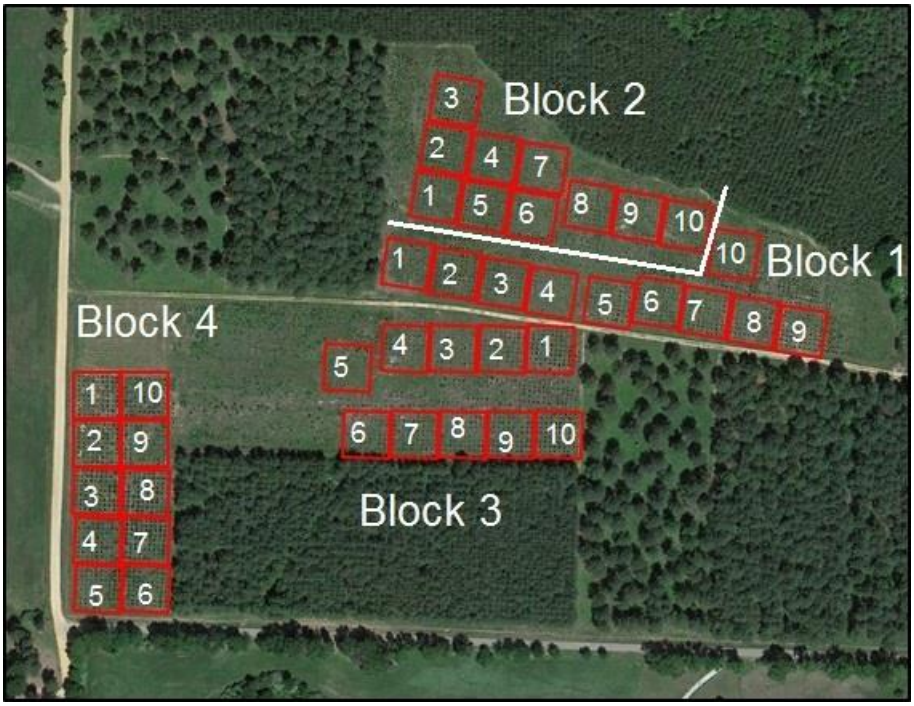

Figure 1--Block and plot layout for the loblolly pine variety trial on the Spencer Tract of the Southwest Research and Extension Center, Hope, AR.

Table 2--Herbicide treatments applied to control competing vegetation

Date	Treatment
March 2009	Velpar, 2 quarts + Oust, 2 ounces per acre
August 2009	Arsenal, 16 ounces + Escort, 1 ounce per acre
March 2010	Velpar, 2 quarts + Escort, 1 ounce per acre
Oct/Nov 2011	Basal bark application of Remedy® to hardwoods and volunteer pines

each of the 10 families of seedlings was represented by one plot in each block. The layout had to be modified as will be explained in the statistical design section. The interior 36 trees of each plot were measurement trees with a 2-tree buffer surrounding the measurement trees for an initial total of 1,440 measurement trees divided among the 40 plots.

This report covers measurements taken by a crew from SWREC on 27 November 2012, after four growing seasons. For each tree the crew recorded tree presence (i.e. survival), tree height measured in feet and tenths of feet, and presence of stem defects such as crooks, sweeps, forks, broken tops, and animal damage. Stem defects were recorded only for those trees alive at the time of sampling. A stem defect rate was calculated for each plot by dividing the number of stems with defects by the number of live stems in the plot.

Statistical Design

The statistical design was originally conceived as a balanced complete random block design consisting of 10 families with four blocks of each family. However, a shortage of the ArborGen MCP-29 family seedlings and the consequent substitution from the ArborGen MCP-22M family resulted in a design that could not be effectively analyzed. ArborGen MCP-29 was represented by only one plot, while ArborGen MCP-22M was represented by two plots in each of three blocks and one plot in the fourth block for a total of seven plots. This problem was resolved by discarding ArborGen MCP-29 from the study and removing three of the ArborGen MCP-22M plots from the study. One ArborGen MCP-22M plot was selected by coin toss from each of the blocks containing two plots of that family and was eliminated from the study. The Arkansas Forestry Commission (AFC) Natural Seedling Mix plot was removed from Block 1 due to poor survival related to poor planting. This resulted in a final statistical design that was an unbalanced complete random block for the survival test. The statistical design for height growth and defect rates were balanced. The data were analyzed using PROC GLM with a Duncan's Multiple Range Test within SAS 9.2 for Windows (SAS Institute 2008). Survival was analyzed as the percent surviving in each plot (n = 4, except the AFC Natural Mix family where n = 3). Defect was analyzed as the percent of trees with a defect in each plot (n = 4). Tree height was analyzed as the average height of all trees within each family with error assigned to blocks (n varies by family).

Climatic Conditions

Climatic conditions in southwest Arkansas during the term of the study have been characterized by extremes of rainfall and higher than normal temperatures during 3 of the 4 years. This has resulted in growing conditions that were less than ideal for loblolly pine seedlings.

Normal annual rainfall accumulation at SWREC is 56.3 inches per year (iAIMS Climatic Data 2013). During 2009, SWREC received 85.4 inches of rainfall. This was followed by 35.0 inches of rainfall in 2010, by 40.0 inches in 2011, and by 44.0 inches in 2012 (Unpublished data. 2012. S. Pote, Administrative Assistant, Southwest Research and Extension Center, 362 Hwy 174N, Hope, AR 71801).

Normal mean high temperatures for June, July, August and September are 88.9, 92.1, 91.9, and 84.4 ^{o}F, respectively. During the course of this study, June mean high temperatures were 90.2, 92.6, 94.3, and 91.5 ^{o}F for 2009, 2010, 2011, and 2012, respectively. July mean high temperatures were 91.1, 92.8, 98.8, and 94.0 ^{o}F for the 4 years. August mean high temperatures were 88.4, 98.2, 101.5, and 93.4 ^{o}F for the 4 years. September mean high temperatures were 80.7, 89.4, 89.0, and 86.7 ^{o}F for the 4 years.

RESULTS

Height Growth

Mean overall height growth for the study was 10.7 feet. Mean height growth for the different seedling families ranged from 8.9 feet to 12.1 feet (table 3). Three ArborGen varieties (34, MCP-22M, and 520) produced the greatest mean height growth. The least height growth was produced by the Weyerhaeuser First Generation seedlings and the AFC Natural Seedling Mix.

Survival

Mean overall survival rate for the study was 82.0 percent. Mean survival rate for the different families ranged from 57.4 percent to 89.6 percent (table 4). Due to very low survival (25 percent), we excluded Block 1 Plot 4 from the survival calculations. Block 1 Plot 4 was the first plot planted by the ADC crew, and we believe the low survival in that plot was partly a result of

Table 3--Mean height growth for the nine loblolly pine families. Means followed by the same letter are not significantly different at p < 0.05

Family	Height	Sample size
	--feet--	
ArborGen 34	12.1a	125
ArborGen MCP-22M	12.0a	125
ArborGen 520	11.8a	118
ArborGen 522	11.2b	113
ArborGen 579	10.4c	118
AFC Imp. mix	10.4c	116
Weyerhaeuser 2^{d} gen.	10.0c	116
AFC Nat. mix	9.3d	67
Weyerhaeuser 1st gen.	8.9d	127

Table 4--Mean survival rate for the nine loblolly pine families. Means followed by the same letter are not significantly different (p < 0.05)

Family	Survival	Sample size
	percent	
Weyerhaeuser 1st gen.	89.6a	4
ArborGen 34	88.9a	4
ArborGen MCP-22M	86.8a	4
ArborGen 520	82.6a	4
AFC Imp. mix	82.6a	4
ArborGen 579	82.6a	4
Weyerhaeuser 2^{d} gen.	81.3a	4
ArborGen 522	79.9a	4
AFC Nat. mix.	57.4b	3

planting crew inexperience and did not accurately reflect the capability of the family. As a result of dropping this plot, the AFC Natural Mix loblolly pine family was represented by only three plots in the survival calculations. Note that the planting crew was halted and retrained after Block 1 Plot 4 was completed.

The statistical analysis did not reveal many significant differences in survival among the nine families. Survival rate for the Arkansas Forestry Commission Natural Mix family was 57.4 percent. This was significantly lower than the survival rate for all of the other families which ranged from 79.9 percent to 89.6 percent.

Stem Defects

Stem defects were recorded only for those trees still alive at the time of sampling. Since all plots experienced some mortality, an analysis of simply the number of stems displaying defect in each plot would have been meaningless. We divided the number of stems with defects by the number of surviving stems in the plot to yield a rate which was analyzed. Mean overall stem defects rate for the study was 12.2 percent. Mean defect rate for the different families ranged from 6.9 percent to 19.6 percent (table 5).

Table 5--Mean defect rate for the nine loblolly pine families. Means followed by the same letter are not significantly different at p < 0.05

Family	Defect	Sample size
	percent	
ArborGen 579	19.6a	4
ArborGen 520	15.0ab	4
ArborGen 522	13.8ab	4
Weyerhaeuser 2^{d} gen.	13.0ab	4
Weyerhaeuser 1st gen.	12.6ab	4
AFC Imp. mix	12.5ab	4
AFC Nat. mix.	9.2b	4
ArborGen 34	7.3b	4
ArborGen MCP-22M	6.2b	4

DISCUSSION

Height Growth

When the tested loblolly pine families are listed from tallest to shortest (table 3), the top three families are two of ArborGen's Atlantic Coast families and one Arkansas sourced family. Two of those are elite families and one is a second generation family. The fourth family is an ArborGen elite family sourced from Arkansas. The ArborGen elite families produced greater height growth than the most of the second generation families. One ArborGen second generation family, AG 34, produced height growth equal to the elite families.

The Arkansas Forestry Commission's Natural Mix family and Weyerhaeuser's first generation family produced the least height growth of the nine families. Families derived from Atlantic Coast sources tended to produce superior height growth compared to those from western Gulf Coastal Plain sources. The Weyerhaeuser first generation family and the AFC Natural Mix family have been subjected to little or no selection for height growth; thus one would not expect superior height growth from these families.

Survival

The lack of significant differences among the top eight families in our study may be explained by either of two ideas. First, our sample size may

have been too small to clearly define survival rates within the narrow range of survival rates of the top eight families. Unfortunately, the size of this study was limited by number of seedlings available to us and space available to install the variety trial. Second, the lack of significance may also be attributed to very good and consistent seedling quality. From an operational viewpoint, the difference between 79.9 percent survival and 89.6 percent survival will rarely matter. When considering the implications of these survival rates, one must keep in mind that these seedlings were planted during a year when annual rainfall was significantly above normal, even though subsequent years were abnormally dry. These survival rates may not accurately reflect the rates that would have been produced had the seedlings been planted during a year of normal or subnormal rainfall.

Stem Defects

Just as with survival, analysis of the stem defect rates was plagued by small sample sizes. The ANOVA divided the nine families into two broadly overlapping groups. Three families (ArborGen MCP-22M, ArborGen 34, and Forestry Commission Natural) had significantly lower defect rates than ArborGen 579 which had the highest defect rate. The remaining five families could not be statistically distinguished from each other or from either end of the defect rate spectrum. There was no clear differentiation between defect rates of Atlantic Coastal families and western Gulf Coastal Plain families. Some Atlantic Coast-derived families were found at each end of the defect rate spectrum.

CONCLUSION

Two loblolly pine families produced by ArborGen (34 and M-22M) ranked among the best families for height growth, survival rate, and defect rate in this variety trial. The remaining seven families tended to rank well in one or two of the tested parameters but poorly in the remaining one or two.

It has been postulated by some that Atlantic Coast families were not well suited to western Arkansas' hot and dry summers. The idea anecdotally presented by some is that height growth might be better but that poor survival would render the stand less productive than loblolly pine derived from western Gulf Coastal Plain sources. In spite of the dryer, or much dryer, than normal summers southwest Arkansas has experienced during the term of this variety trial, loblolly pine families derived from Atlantic Coast sources did not suffer reduced height growth or poorer survival compared to families derived from western Gulf Coastal Plain sources. This is consistent with the findings of Will and others (2010) in southeastern Oklahoma. These preliminary results present no evidence to suggest that one should select loblolly pine families derived from western Gulf Coastal Plain sources over those derived from Atlantic Coast sources based solely on height growth and survival.

Be aware that these are preliminary results after only four growing seasons. Much can change through the next 10 to 15 years. Also bear in mind that this study examines seedlings grown on one site. Different soils or moisture regimes may yield different results.

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