GENETIC VARIATION AMONG OPEN—POLLINATED FAMILIES OF BALDCYPRESS SEEDLINGS PLANTED ON TWO DIFFERENT SITES

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Abstract.--After two years of growth on two different sites in south Louisiana, baldcypress seedlings averaged 126.3 cm in height and 2.05 cm in diameter. Available soil moisture significantly influenced seedling growth between the two sites, with the wetter site producing the largest seedlings. Geographic variation was not found. However, family—within—source variation was significant for both height and diameter.

Additional keywords: crawfish, geographic variation, Procambarus clarkii, Taxodium distichum.

Baldcypress [Taxodium distichum (L.) Rich.] is an important commercial species in the swamps and bottomlands of the southern and southeastern United States. Throughout the South, there is an estimated 5.5 billion ft^3 (155.7 million m^3) of baldcypress growing stock on 3 to 5 million acres of commercial timberlands (Williston et al. 1981). Much of this timber will reach merchantable size within the next 30 years. Baldcypress is adapted to permanently or periodically flooded sites that are difficult to restock by natural regeneration. Before existing stands of cypress are harvested, an alternative method of regeneration must be investigated to improve cypress resources for future demands. Planting of baldcypress seedlings is a viable alternative, and numerous successful plantings have been reported (Bull 1949, Foil and Merrifield 1966). Researchers at Louisiana State University are studying the genetic variation of baldcypress in an effort to enhance knowledge of regeneration and management techniques.

METHODS

Seedlings from 26 half—sib baldcypress families representing 9 geographic seed sources (fig. 1) were planted at two locations in southern Louisiana in early 1983. The 1-0 seedlings had been grown at the Louisiana State University, School of Forestry, Wildlife, and Fisheries nursery at Baton Rouge, LA. Field design was a ten—replicate, randomized block design with five—tree—row family plots. Seedlings were planted on a 3—m x 3 ¯m spacing, and a single row of border trees was planted around each plantation. All seedlings were root—pruned to eight inches to facilitate planting and graded by height and diameter. The largest seedlings of each family were planted in block 1, and successively smaller seedlings were planted in later blocks.

The first out—planting is located on the Thistlethwaite Wildlife Management Area in St. Landry Parish, Louisiana. This site had been under cultivation for approximately 25 years prior to which it was a bottomland hardwood site. The soils at the Thistlethwaite ᵖlantation consist of approxi¯mately 80 percent Baldwin silty clay loam and 20 percent Dundee silty clay loam (USDA Soil Conservation Service 1976). The second plantation is on a

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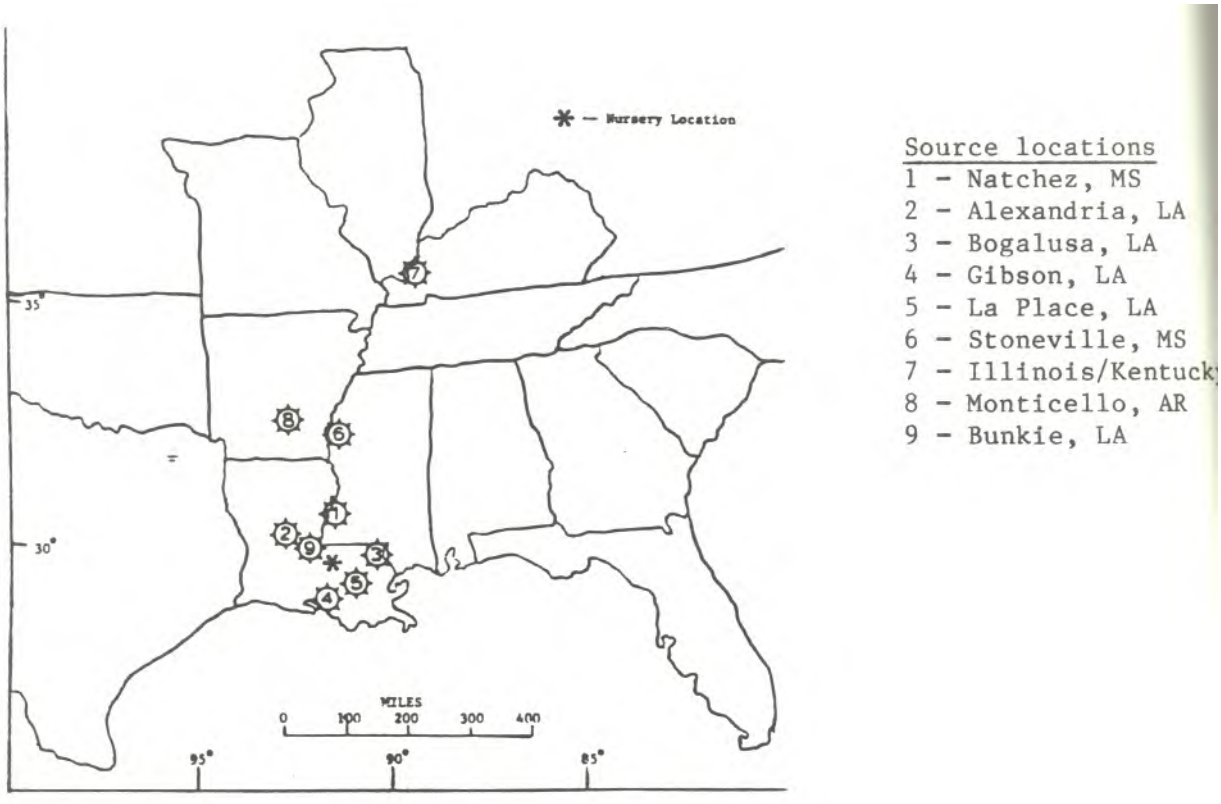

Figure 1. Relative location of selected geographic seed sources of baldcypress (Adapted from Faulkner and Toliver 1983).

bottomland hardwood/swamp site owned by the St. Martin Land Company in St. Martin Parish, Louisiana. This site was cleared of timber and diked for management as a crawfish (Procambarus clarkii) pond. The soil here is a Sharkey clay (Murphy et al. 1977). The St. Martin plantation was flooded with water to a depth of 20 cm for 2-3 weeks in May 1983 to stock the site with crawfish and then was inundated again from October 1983 through May 1984 for crawfish production. Both plantation sites were disked prior to planting, and weed competition after planting was controlled by a combination of disking, mowing, and herbicide applications. Soil moisture and climatic factors were monitored and recorded on a bi-weekly basis at each plantation from April through September of 1983.

An analysis of variance on the height and diameter of the seedlings taken at the time of planting indicated several significant differences attributable to the seedling grading procedure. Therefore, in order to remove the effect of this initial variation, geographic source and family components of the 3-year-old seedlings were examined by analysis of covariance using the General Linear Model (GLM) procedure of the Statistical Analysis System (SAS) (SAS institute 1982). Further adjustment of the statistical model was necessary because of animal damage to seedlings that occurred at both plantations. In the early summer of 1983, white-tailed deer (Odocoileus virginianus) browsed 47.2 percent of the seedlings at the Thistlethwaite plantation. In the spring of 1984, crawfish either partially or completely girdled 77.8 percent of the

seedlings at the St. Martin site. In both cases the damage rate was negatively correlated to the height and diameter of 1-0 seedlings. In order to remove the effect of seedling damage on the genetic and site components of the statistical model, a damage factor was added for analysis of covariance of the 3—year—old seedling data.

RESULTS AND DISCUSSION

Site Variation

After two growing seasons in the field, the combined survival rate of the two plantations was 96.4 percent. The Thistlethwaite seedlings had a survival rate of 98.3 percent, while survival at St. Martin was 94.5 percent. Combined mean height was 126.3 cm and mean diameter was 2.05 cm. Analysis of covariance indicated a highly significant difference in height and diameter of seedlings between the two plantations. Mean height and diameter at Thistlethwaite were 125.8 cm and 1.72 cm, respectively, as compared with a mean height of 127.2 cm and a mean diameter of 2.40 cm for the seedlings at the St. Martin plantation. Mean growth at Thistlethwaite was 15.2 cm in height and 0.60 cm in diameter as compared to a growth of 28.1 cm in height and 1.48 cm in diameter at the St. Martin site. The superior growth rate of the St. Martin seedlings is attributed to the more favorable soil moisture conditions at this site brought about by the periodic inundation of the plantation area for crawfish production. Since baldcypress is naturally adapted to bottomlands subjected to seasonal flooding, the spring and early summer flooding of the St. Martin site did not hamper seedling growth. Instead it appeared to enhance growth by delaying the development of weeds and summer moisture stress conditions, therefore promoting early height and diameter growth. Precipitation and temperature were not significantly different between the two sites.

Genetic Variation

Geographic variation was not significant for either height or diameter of the 3—year—old seedlings. Faulkner and Toliver (1983) found a similar lack of geographic variation among 1-0 baldcypress seedlings. It is possible that the scope of both studies was not large enough to detect geographic variation. Only localities along the Mississippi River floodplain were sampled, while testing of provenances from a wider range might have provided more geographic diversity. This could also be a result of seed dispersal down the Mississippi River during flood conditions. Flood waters could easily have carried seed from northern sources southward, resulting in less genetic diversity among provenances along the floodplain.

Family—within—source variation was significant for height ($p<.05$) and highly significant for diameter ($p<.01$) of the 3—year—old seedlings (table 1). Thus it appears that there is greater genetic diversity among individual trees within natural baldcypress stands than among provenances. The wide range of variability among families points to a potential for genetic gain in the growth of baldcypress through family selection. If the best three families (top 10 percent) were selected for mean height (table 2), one each would come from the Stoneville, MS; Gibson, LA; and La Place, LA sources resulting in a realized gain of 13.3 percent (16.8 cm). A gain of 17.6 percent (0.36 cm) in diameter can be obtained by selecting the best three families, two families from the Stoneville source and one from the Gibson source (table 2). These

Table 1.--Analysis of covariance of baldcypress seedling heights and diameters after two growing seasons on two different sites in Louisiana.

Source of variation	Degrees of freedom	Mean squares	
		Heights	Diameters
Damage = D	3	81739.89	41.07
Plantation = P	1	86166.83[a/]	128.94[a/]
Block-within-plantation = B(P)	18	2155.90[a/]	1.33[a/]
D x B(P)	27	566.35	0.46
Source = S	8	1086.49	0.42
D x S	24	693.04	0.28
P x S	8	783.17	0.64--
B(P) x S	144	485.32	0.26
Family-within-source = F(S)	17	906.571[b/]	0.52--
P x F(S)	17	285.94	0.16
Error	597	407.36	0.22

[a/] Significantly different at the .01 level of probability.
[b/] Significantly different at the .05 level of probability.

gains could be extremely important to the successful establishment of baldcypress plantations. Planting of larger seedlings could overcome the problems of periodic high water levels, weed competition, and animal damage, and thus result in higher survival rates. It should be remembered, however, that rapid early growth in either height or diameter of a particular family does not necessarily indicate that gains will continue through an entire rotation. Further testing is essential to determine if the magnitude of these family gains and rankings will remain consistent.

Genotype x Environment Interaction

Plantation-by-source interaction was significant ($p<.05$) for seedling diameter (table 1). This genotype x environment interaction indicates that some geographic sources of baldcypress may be site specific. Certain sources performed very well on one site and poorly at the other in comparison to the other sources. In particular, the Stoneville source ranked first at the St. Martin site with a mean diameter of 2.91 cm, but dropped to seventh place at the Thistlethwaite site with a mean diameter of 1.67 cm. The Natchez, MS source was second at the Thistlethwaite plantation (mean diameter = 1.79 cm) and ranked ninth at St. Martin (mean diameter = 2.07 cm). If this interaction

continues to exist after further testing, then future plantings should be made by matching provenances to the proper site to obtain maximum tree growth.

Table 2.-Ranking of families by height and diameter across both plantations.

Seed Source	Family Code a/	Mean height	Mean diameter
		- - - - - (cm) - - - -	
Stoneville, MS	6-4	147.75	2.51
Gibson, LA	4-2	140.84	2.32
La Place, LA	5-2	140.68	2.26
Stoneville, MS	6-2	140.47	2.39
Alexandria, LA	2-3	139.88	2.26
Gibson, LA	4-1	135.46	2.19
Stoneville, MS	6-3	132.54	2.30
Alexandria, LA	2-1	131.66	2.21
La Place, LA	5-1	131.10	2.09
Stoneville, MS	6-1	131.06	2.19
La Place, LA	5-5	127.31	1.86
Bogalusa, LA	3-5	125.94	2.02
Bunkie, LA	9-2	125.14	2.08
Bunkie, LA	9-3	125.07	1.89
Bunkie, LA	9-4	124.58	1.95
Monticello, AR	8-2	124.03	2.19
Monticello, AR	8-6	123.09	2.12
La Place, LA	5-3	122.52	1.93
La Place, LA	5-4	121.68	1.84
Bunkie, LA	9-5	116.26	1.80
Natchez, MS	1-2	116.19	1.79
Illinois/Kentucky	7-2	115.86	1.78
Illinois/Kentucky	7-3	115.57	1.82
Monticello, AR	8-1	115.55	2.01
Illinois/Kentucky	7-1	107.45	1.66
Illinois/Kentucky	7-4	105.58	1.86

a/ The first number refers to geographic seed source (see fig. 1), and the second number refers to family-within-source.

CONCLUSIONS

Site conditions are important to height and diameter growth of baldcypress seedlings. Adequate available soil moisture is of particular importance in this respect and should be considered in site selection. Significant family variation for both height and diameter and potential early growth gains through family selection warrant the further testing of baldcypress families. Also, the existence of a genotype x environment interaction indicates the need for progeny testing of baldcypress over a wider range of sites to increase the potential for gains through consideration of site characteristics. Finally, the planting of larger seedlings (taller than 1.0 m in height and larger than 1.25 cm in diameter) should reduce the incidence of crawfish damage and deer browse and improve early survival and growth.

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