Height and Diameter Growth Differences Among Eight Cherrybark Oak Provenances

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Cherrybark oak (*Quercus pagoda* Raf.) is an important and highly valued southern hardwood timber species. Previous studies have shown that growth differences do exist among provenances (Greene et al. 1991). Yet this study did not identify any geographic trend in seed source productivity. Substantial variation among families within provenances was also observed by Greene et al. (1991) leading to the recommendation that provenance considerations as well as individual family considerations must be made when making selections.

The objective of this study was to identify growth differences among various seed sources. Determination of potential genetic gains through selection was conducted through estimation of heritability and calculation of genetic gain. Finally, the ability to select for volume at age 15 from juvenile measurements was evaluated through age-age correlations.

METHODS

A cherrybark oak provenance-progeny test was established in 1987 on MeadWestvaco property located in Carlisle Co., Kentucky. The test site is on a loess bluff just south of the confluence of the Mississippi and Ohio Rivers. The silt-loam site is composed of the Grenada and Memphis-Loring series. The planting site was previously in agriculture production until 1983, but had been fallow until the spring of 1987. Site preparation included disking and sub-soiling prior to planting.

The experimental design was a split block design, eight provenances per block forming the main plots and three to five families per provenance. A total of 37 half-sib families represented the eight provenances, with each family arranged in a five-tree-row sub-plot and planted at a nine-by-nine-foot spacing. Provenances included: Bienville Parish, LA (LA1), Washington Parish, LA (LA2), Okitibbeha Co., MS (MS1), Warren Co., MS (MS2), Washington Co., MS (MS3), Fayette Co., TN (TN1), Lauderdale Co., Haywood Co, Fayette Co., Weakly Co., TN (TN2), and Southampton Co. VA (VA1). Height measurements were taken at ages one, three, five, ten, and fifteen. DBH measurements were taken at ages five, ten, and fifteen. Volume (cubic feet) was calculated using the volume equation: volume = [0.00007854xDBH (cm) ^{2}] x height (m).

Overall differences between provenances and families within provenances were tested using the ANOVA and Duncan's New Multiple Range Test. Both diameter and height were analyzed at each age of measurement. Estimates of narrow-sense individual tree (h^2), family (h_f^2), and within-family heritabilities (h_w^2) and genotypic and phenotypic correlations were calculated from the estimated variance and covariance components (Becker 1975). The indirect gains estimated by the correlation response (CR) were derived from Falconer and Mackay (1996).

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RESULTS AND DISCUSSION

Early-age survival was generally good in this study for all provenances. Survival percentages remained above 90 percent for all provenances from ages one to ten. At age 10, the Bienville Parish, Louisiana, provenance exhibited the best survival at 97.3 percent, while Okitibbeha Co., Mississippi provenance was the lowest at 92 percent. The high survival rates among all provenances can be attributed to proper site selection, intense grading of the seedlings prior to planting, and the maintenance of the site following planting. Between ages 10 and 15, survival was shown to decrease rather sharply, most certainly related to spacing as the 2.7-by-2.7-meter spacing is creating intense tree-to-tree competition.

Provenance differences did exist for height and diameter at each measurement. Duncan's new multiple range test showed that differences between the individual provenances were small and in many cases not significant. The two best performing provenances for height and diameter at age 15 were from counties Washington and Warren in Mississippi. While these two superior provenances as well others changed little in rank over time, the provenance from Washington Parish, Louisiana, moved to a higher rank for both height and diameter. Significant differences also occurred among families within provenances for both height and diameter at all ages highlighting the need for family considerations when selecting within a seed source.

Variation among families allows for potential gains to be made through selection within provenances. Family heritabilities ranged from 0.50 to 0.70 for height and 0.55 to 0.70 for diameter. This was much greater than the individual tree heritabilities which ranged from 0.17 to 0.28 for height and 0.20 to 0.36 for diameter. All height heritabilities were high at age one, dropped at age three, and had a modest increase over time until age 15 where there was a slight decrease. Excluding age-one estimates, heritability tended to peak at age ten for all traits and then remain steady or drop by age 15. Overall, dbh heritability was the highest among the three traits. Volume family-heritability ranged from 0.40 to 0.65 which is comparable to height.

Family selection yielded more gains per unit time than combined selection when using height at any age, while selection based on diameter or volume favored a combined selection (Table 1). All traits showed promise at various ages for selection purposes. Combined selection based on dbh, specifically at age-ten, will allow the most gain per unit time to be made. Genetic correlations with volume at age 15 ranged from 0.74 to approximately 1.0. Both age-five dbh and age-ten volume had correlations that were approximately one. However, genetic gains per unit time were highest using selection of DBH at age-ten.

Table 1. Age-age correlated response and genetic gains per unit time with age 15 volume from indirect selection in the 1987 Cherrybark oak provenance test in Carlisle Co., Kentucky.

	Correlated Response with Age 15 Volume				Genetic Gain Per Unit of Time[b]	
Selected Trait[a]	Family Selection		Combined Selection		Family	Combined
	(m^3)	(%)[d]	(m^3)	(%)[d]	(%)[c]	(%)[c]
Age 1 Height	0.193	6.0	0.017	5.2	0.54	0.35
Age 3 Height	0.027	8.4	0.020	6.3	0.64	0.42
Age 5 Height	0.027	8.4	0.023	7.1	0.55	0.47
Age 10 Height	0.027	8.4	0.021	6.4	0.42	0.43
Age 5 DBH	0.016	4.9	0.025	7.7	0.33	0.51
Age 10 DBH	0.037	11.6	0.036	11.2	0.57	0.75
Age 5 Volume	0.015	4.7	0.019	6.1	0.31	0.41
Age 10 Volume	0.037	11.6	0.035	10.7	0.58	0.72

[a] Selection intensity for family selection was 2/37 families(i=2.023) and for combined selection was 5/37 families (i=1.8175) and 10/26 individuals within families (i=0.993). These values were chosen so that a similar number of trees were selected by each method.
[b] Unit time is defined as selection age plus 10 years for family selection and 15 years for combined selection.
[c] Percent response-correlated response (m^3)/average age 15 volume (0.32 m^3).
[d] Percent gain per unit of time-percent response/unit time

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