VARIATION IN 10-YEAR GROWTH OF NORTHERN RED OAK FROM PROVENANCES IN THE TENNESSEE VALLEY

by

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INTRODUCTION

One of the first problems faced in a breeding program is determining the most effective method of selecting breeding material from a natural population. Effectiveness of mass selection depends upon the pattern of natural variation. In 1965, when the Tennessee Valley Authority began genetic research with northern red oak (*Quercus rubra* L.), the pattern of species genetic variation in the Tennessee Valley was unknown. The test described here was a small-scale evaluation of the relative amount of variation (1) among major geographic provenances in the Valley and (2) within single stands. Results were to be used in developing a strategy for selection from the Valley population. It has been used further to assess response of red oak to nitrogen fertilization and to evaluate genotype nitrogen interactions. This report covers the first 10 years of study.

METHODS

Seed were collected from 55 parent trees in six stands (table 1) in fall 1966. Two stands were in eastern Tennessee, one in middle Tennessee, and two in the western part of the Tennessee Valley. A sixth stand in central Ohio, near the center of northern red oak's range, was sampled to evaluate the performance of a more northern source relative to local material.

All parent trees were of good form and contained at least one good butt log. The volume of a single lot of 100 acorns per tree was determined by water displacement to assess average acorn volume; tree means ranged from 3.2 to 7.1 cc.

Three replications of seedlings from each parent were grown in a nursery near Norris, Tennessee (latitude 36° N, longitude 84° W), and field planted nearby the following spring in Pope very fine sandy loam soil.

The field planting had seven replicates of a nested design, with stands as main plots and families within stands as subplots. Each subplot included 12 seedlings planted in two rows of 6; spacing was 9 feet between rows and 4 feet between trees within rows.

The site, which had a sod of Kentucky-31 tall fescue, was plowed once and disced three times before planting. Seedlings were planted by dibble,

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Table 1.--Location of northern red oak stands used as sources of open-pollinated familes

Stand	No. of parent trees	Latitude N	Longitude W	Elevation (ft)
Ohio	8	40°45'	81°55'	961
Western Kentucky	5	36°49'	88°02'	500
Central Peninsula	11	36°20'	83°57'	1300
Norris Dam	10	36°12'	84°05'	1100
Cumberland Plateau	10	35°44'	85°22'	1200
North Alabama	5	34°31'	86°57'	550

and a fertilizer pellet (18-R-3, with 1 percent magnesium and 3 percent potash) was placed in the backhole. Simazine was applied in 1968 to control fescue, and the planting was mowed annually between rows.

In May 1971 six blocks were grouped into three replications of two blocks each. Trees in one of these two blocks each received .22 pound of ammonium nitrate spread in a 2-foot-diameter circle; trees in the other block were untreated.

Total height of each tree was measured to the nearest 0.1 foot each October, 1968, 1969, 1970, 1972, and 1977. In September 1972, diameter to the nearest 0.1 inch was measured at 1.0 foot above the ground. Diameter at breast height to the nearest 0.1 inch was measured in 1977. Date of budbreak was recorded in 1970, 1971, and 1972 (Gall 1973). Prior to the 1977 measurement, plots were thinned to about six trees.

RESULTS AND DISCUSSION

Observations through 1972 were summarized by Gall (1973) and Gall and Taft (1973) using data from 49 families that were represented in all replications. A combined analysis to evaluate effects of stands and families within stands revealed that family differences were significant (.05 level of probability) throughout the first five years and that material from the western Kentucky stand was significantly larger than material from other stands (table 2). Narrow-sense heritabilities for height based on families within-source variances (see Gall 1973, pages 47 and 48) were as follows:

Year	h^2
1968	.66
1969	.33
1970	.30
1972	.37

Table 2.--Heights of northern red oak from six sources during first 10 years of testing at Jones Island site

Stand location	Height, ft				
	1968	1969	1970	1972	1977
Western Kentucky	1.7	2.4	3.3	5.2	17.9[a/]
Norris Dam	1.7	2.2	2.9	4.3	15.0 b,c
North Alabama	1.6	2.2	2.8	3.9	16.0 a,b
Ohio	1.3	1.7	2.4	3.4	11.5 d
Norris Lake	1.3	1.8	2.4	3.2	12.9 c,d
Cumberland Plateau	1.2	1.7	2.4	3.2	12.6 c,d

a/ For 1977 data, means with different letter suffixes are significantly different based on Duncan's Multiple Range test at the .05 level of probability.

Height growth was stimulated by nitrogen fertilization during the 1971 growing season, and by the end of 1972, fertilized trees averaged 4.6 feet, while unfertilized ones averaged 3.7 feet in height. Budbreak date was strongly related to latitude of stand, with material of southerly origin beginning growth earliest. During the first five years, height was positively correlated with earliness of budbreak and number of shoot elongation flushes per season. Height growth positively correlated with acorn size only during the first three years.

Height, diameter, and volume (D^2H) at 10 years are summarized in table 3. These growth parameters were analyzed using plot means and the split plot design outlined in table 4. Mean tree volumes were computed from mean diameter and height of trees in family subplots. Within-plot variance for height and diameter was computed from every 10th plot.

Trends and relationships established at 5 years continued through 10 years (tables 2 and 3). Fertilized trees were on the average about 18 percent taller than unfertilized ones, a reduction from the 24-percent difference noted at five years. However, the difference in D^2H was more dramatic: Fertilized trees had volumes averaging 70 percent greater than controls at 10 years. The fertilizer x genotype interaction was nonsignificant for height and diameter, but the stand x nitrogen interaction was significant for volume. This latter interaction was based on wide differences in the degree of response to nitrogen, from 21 percent for Norris to 121 percent for the Ohio stand.

Table 3.--Ten-year height, diameter, and volume of northern red oak from six sources

Source		Height, ft		Diameter, in.		Volume, D^2H	
		Control	Fert.	Control	Fert.	Control	Fert.
Western Kentucky	Mean	17.4	20.9	2.0	2.5	80.0	146.6
	Range of family means	13.8-20.7	15.1-23.2	1.3-2.5	1.6-2.9	35.1-130.2	48.8-195.1
Northern Alabama	Mean	13.6	17.0	1.6	2.1	41.1	76.5
	Range of family means	12.4-14.6	16.1-18.2	1.3-1.8	1.9-2.2	32.8- 50.7	59.1- 89.5
Norris Dam, Tennessee	Mean	14.5	15.3	1.5	1.7	42.3	51.3
	Range of family means	10.8-17.5	12.5-19.5	1.0-1.9	1.3-2.1	23.3- 65.0	23.9- 91.9
Norris Lake, Tennessee	Mean	11.1	13.2	1.1	1.4	23.9	37.3
	Range of family means	6.5-15.4	8.0-16.8	0.5-1.6	0.7-1.9	8.8- 59.4	22.4- 61.7
Cumberland Plateau, Tennessee	Mean	11.8	12.7	1.1	1.4	27.0	42.2
	Range of family means	8.3-18.1	7.0-17.0	0.7-1.9	0.6-2.0	7.9- 68.9	6.3- 86.4
Wooster Ohio	Mean	9.9	13.0	0.9	1.4	14.2	31.4
	Range of family means	5.4-11.8	11.2-16.3	0.7-1.2	1.1-1.9	7.9- 24.8	16.3- 64.9

Table 4.--Analysis of variance: Ten-year growth characteristics of northern red oak open-pollinated families from six geographical sources

Source of variation	df	Height		Diameter		D^2H		Expected mean square
		Mean square	Variance	Mean square	Variance	Mean square	Variance	
Replication (R)	2	162.04		1.52		7,530		$\sigma^2_{w/k} + \sigma^2_p + 49\sigma^2_{RN} + 98\sigma^2_R$
Fertilization (N)	1	307.71		7.02		36,584		$\sigma^2_{w/k} + \sigma^2_p + 3\sigma^2_{FN} + 22.67\sigma^2_{SN} + 45.27\sigma^2_{RN} + 135.82\sigma^2_N$
N x R (Error I)	2	58.70		1.60		3,053		$\sigma^2_{w/k} + \sigma^2_p + 49\sigma^2_{RN}$
Source (S)	5	204.26*	4.59	4.87*	.09	26,357*	476.47	$\sigma^2_{w/k} + \sigma^2_p + 3\sigma^2_{FN} + 6\sigma^2_F + 24.07\sigma^2_{SN} + 48.15\sigma^2_S$
N x S	5	13.16	.02	.27	.00	2,647*	66.60	$\sigma^2_{w/k} + \sigma^2_p + 3\sigma^2_{FN} + 24.07\sigma^2_{SN}$
Families/Source (F)	43	19.20*	1.10	.44*	.03	1,812*	174.00	$\sigma^2_{w/k} + \sigma^2_p + 3\sigma^2_{FN} + 6\sigma^2_{FN}$
N x F	43	12.60	.11	.28	.01	1,044	0.00	$\sigma^2_{w/k} + \sigma^2_p + 3\sigma^2_{FN}$
Error II	192	12.26	10.73	.27	.22	1,156	1,156.00	$\sigma^2_{w/k} + \sigma^2_p$
Within plot			1.53		.05			$\sigma^2_{w/k}$
TOTAL	293							

*Statistically significant at the .05 level of probability.

Stand effects remained the major source of genetic variance, and there were only minor changes in ranking between 1972 and 1977. Material from the western Kentucky and north Alabama stands was largest, and that from Ohio the smallest.

Narrow-sense heritabilities computed using the family within-stand component of genetic variance (table 4) were .33 and .39 for 10-year height and diameter, respectively. These heritabilities are roughly the same as those computed by Gall (1973) from five-year data.

Correlations of family means for height between 5 and 10 years suggest that patterns now established will persist:

Relationship	r
1 yr vs 5 yrs	.64
1 yr vs 10 yrs	.64
5 yrs vs 10 yrs	.95

In summary, results to date suggest that variation among stands within a relatively small portion of the species range, such as the Tennessee Valley, may be a valuable source or genetic variance in growth potential. Since stands were confounded with geographical provenance in this study, one cannot, on the basis of results, determine that western seed sources perform better than eastern ones on an eastern site. However, trends existing at 10 years suggest that this relationship warrants further investigation. The selection potential presented by stand-to-stand variation, together with ample within-stand variance and a relatively high narrow-sense heritability, indicates that some major opportunities exist for improving the performance of planted oak.

LITERATURE CITED

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