VARIATION BETWEEN AND AMONG ENGLISH OAK AND WHITE OAK FAMILIES IN SURVIVAL AND EARLY GROWTH

by Knud E. Clausen, Principal Plant Geneticist,
North Central Forest Experiment Station,
Forestry Sciences Laboratory,
Carbondale, Illinois 62901

ABSTRACT.--Survival and height of 62 English oak and 10 white oak families in a southern Illinois plantation were recorded annually for the first 5 years after planting. Survival did not differ between species but varied significantly among the English oak families. Height varied among families at time of planting for white oak and in all years for English oak. Mean 5-year height was 144 for white oak and 154 cm for English oak; the family component accounted for 24 percent of the variation in the English oak. Block x family interactions were significant for both species. The best English oak family was 59 percent taller than the best white oak family, but one-third of the English oak families were shorter than the poorest white oak family. Some families have performed consistently; others have varied greatly from year to year.

English oak (*Quercus robur* L.) is found from the Atlantic Ocean eastward to the Ural Mountains and the Caspian Sea and from Scotland and southern Scandinavia southward to Spain, northern Africa, and Turkey (Jovanovic and Tucovic 1975). In its native range, the species is an important timber tree that produces high-value veneer but is also much used for amenity purposes. Although English oak has been grown as a shade tree in the northeastern United States for more than a century, its potential as a timber species in this country was overlooked. Then, in 1969 Wright reported that English oak grown from seed in southern Michigan averaged 3.6 m (12.0 ft) in height at age 9 compared with 2.2 m (7.2 ft) for white oak (*Q. alba* L.). At age 13, the two species averaged, respectively, 6.9 and 4.8 m (22.8 and 15.8 ft) in height and 9.6 and 4.6 cm (3.8 and 1.8 inches) in dbh (Wright *et al.* 1973). Because the Michigan plantations only include progenies of three English oaks and one white oak parent, we decided to test many English oak families and to compare them with several white oak families.

METHODS

In the fall of 1974, we received acorns collected by Dr. Jonathan W. Wright from 69 English oak trees on the Michigan State University campus at East Lansing, Michigan. These roadside trees had been purchased from a commercial nursery and their geographic origin is unknown. In addition, we collected seed from 10 white oak and one English oak in the vicinity of Carbondale, Illinois. In October 1974, the acorns were sown at the Union County Nursery near Jonesboro, Illinois, and the beds were covered with 5 cm of sawdust.

The seedlings were lifted in the fall of 1975, bundled, and kept in cold storage until the following March when they were planted on the Trail of Tears State Forest in Union County, Illinois. Only 62 English oak families and the 10 white oak families were planted because some seedlots germinated poorly, The seedlings were planted in a randomized block design with 5-tree plots and 5 replications at a spacing of 3.66 m (12 ft) between rows and 1.83 m (6 ft) within rows. The site is on Haymond silt loam and had been planted in corn the previous year; therefore, no ground preparation was done before planting. After planting, a 1.2 m-wide strip along each row was sprayed with Simazine herbicide at a rate of 5.6 kg of active ingredients per ha. The herbicide treatment was repeated in the spring of 1977 and as needed in the following years. The area between the rows was mowed annually.

Seedling height was measured and recorded at the time of planting and at the end of each of the first five growing seasons, as was survival. The data were subjected to analyses of variance after arcsin transformation of survival percentages. Plot means were used in the analyses of each species separately as well as in the analyses of all 72 families combined, Additional analyses of 5-year heights were based on individual tree data in order to test for block x family interactions.

RESULTS

Survival averaged 74 percent after the first growing season in the field and 71 percent after the fifth (table 1). Although family differences in the combined analysis were significant in all but the first year, the nonsignificant linear contrasts show that the species did not differ from each other in survival (table 1). The results of the individual species analyses revealed that the family differences in the combined analysis

Table 1.--Mean survival of 62 English oak and 10 white oak families by years and test of differences between and within species.

Year	Survival: English oak	Survival: White oak	Survival: Planta-tion	Species difference[a]	Family difference[a]: English oak	Family difference[a]: White oak
	Percent					
First	74.1	72.8	73.9	NS	NS	NS
Second	73.2	73.2	73.2	NS	***	NS
Third	72.6	73.6	72.8	NS	***	
Fourth	72.2	71.6	72.1	NS	***	
Fifth	79.9	70.8	70.9	NS	***	

[a] NS = nonsignificant
.. = significant at the 0.001 level of probability.

were due to significant differences among the English oak families because the white oak families did not vary (table 1). Survival of individual white oak families ranged from 56 to 92 percent. In comparison, English oak survival ranged from 44 to 100 percent, suggesting greater variability within this species. Significant block differences in all years contributed to the total observed variation, and block x family interactions may have obscured some family differences.

Mean seedling height of both species combined at the time of planting was 31 cm but had decreased to 27 cm at the end of the first growing season, apparently due to first-year dieback. Thereafter, height increased steadily to an average of 153 cm after 5 years in the field (table 2). Family differences in the combined analysis were significant in all years of measurement, but the linear contrast of species was significant only for initial height and for 4-year height (table 2) when the English oak was, respectively, 11.7 and 13.8 percent taller than the white oak. In other years the species differences ranged from 0 to 7 percent.

English oak seedlings increased from an initial height of 31 cm to a 5-year height of 154 cm and differed significantly among families at all times (table 2). The range of family means varied from a minimum of 76 percent of the species mean after the first year in the

Table 2.--Mean height of 62 English oak and 10 white oak families by dates and test of differences between and within species.

Species	Height: Spring 1976	Fall 1976	Fall 1977	Fall 1978	Fall 1979	Fall 1980
	– – – – – – – – – cm- - - - - - - - - -					
English oak						
Mean	31.4	27.2	47.8	72.0	108.5	154.0
Stand. dev.	4.5	7.0	17.2	25.9	32.4	41.2
Family range	17-51	17-37	22-100	28-144	54-240	85-291
White oak						
Mean	28.1	27.2	45.1	69.2	95.3	144.0
Stand. dev.	3.5	5.5	14.7	26.1	30.0	43.9
Family range	21-34	21-31	39-55	63-80	79-118	30-183
Plantation mean	31.0	27.2	47.4	71.6	106.8	152.7

Comparison	Species and family differencesa					
English vs. white	***	NS	NS	NS	***	NS
English oak	***	***	***	***	***	***
White oak	***	NS	NS	NS	NS	NS

[a] NS = nonsignificant
*** = significant at the 0.001 level of probability.

field to a maximum of 173 percent after 4 years. Mean height of the white oaks increased from 28 to 144 cm but only differed among families at the time of planting when the family range was 47 percent of the species mean (table 2). The smallest difference among white oak families (28 percent) was after 3 years.

Because there were significant block differences in height in all years, I used the 5-year heights of individual trees to test for block x family interactions. This analysis excluded one block with poor survival and

included only families that had at least 60 percent survival in any of the four other blocks. Therefore, the analysis only included 25 English oak families and 4 white oak families. The results of this analysis were similar to those of the original one with respect to block and family differences but did show that block x family interactions in 5-year height were significant for the 29 families combined as well as for each species (table 3). There was no obvious cause of these interactions. The block x family interaction accounted for 25 percent of the variation in 5-year height of the white oak families and for 9 percent of the variation in English oak in which the family component accounted for 24 percent (table 3). Trees within plots also varied greatly and accounted for 56 percent of the variation in English oak and for 48 percent in white oak.

Table 3.--Analysis of variance of 5-year height in 25 English oak and 4 white oak families.

Families included in analysis	Significance of F-test[a]		
	Blocks	Families	Blocks x families
All families	***	***	***
English oak	***	***	***
White oak	***	NS	***

Species	Variance components[b]			
	Blocks	Families	Blocks x families	Within plots
	- Percent -			
English oak	10.9	24.4	9.0	55.7
White oak	27.0	0	24.6	48.4

[a] NS = nonsignificant
*** = significant at the 0.001 level of probability.

[b] As percent of total variance.

Although the mean height of the English oak usually exceeded that of white oak, the best white oak family was always taller than the average English oak. After 5 years in the field the best English oak family was 59 percent taller than the best white oak family; on the

other hand, the poorest white oak family was 52 percent taller than the poorest English oak family. The best white oak family after 5 years ranked 19th and the poorest ranked 49th out of the 72 families studied. Thus, nearly one-third of the English oak families were shorter than the poorest white oak family.

DISCUSSION

In general, trees of the two species survived the first 5 years in the field equally well. That the English oak families varied more than the white oak families, however, may partly be because only 10 white oak families were included in this test. Similarly, more height variation would be expected among the white oaks if more families had been included. Farmer and Cunningham (1980) found much family variation in shoot growth of white oak.

The average 3-year height of English oak in our study (72 cm) was 10-20 cm less than the heights reported by Johnson (1981) for English oak of the same age planted in a Missouri clearcut. However, 14 of the families in our study were taller than the greatest mean height (92 cm) among cultural treatments Johnson reported. The best family exceeded this value by 56 percent. Thus, height of the trees was similar in both locations but more variable in our study which included more families and, hence, represented a larger gene pool. We expected the large amount of family variation observed in this study because much family variation in growth, phenology, and wood characteristics of English oak have been reported from studies in Europe (Jovanovic and Tucovic 1975).

That the English oak seedlings were significantly taller than the white oak seedlings at the time of planting probably reflects the rapid early growth from seed of English oak, described by Wright (1969). In the years after planting, height differences between English and white oak were significant only in the fourth year. Climatic conditions during the 1979 growing season may explain this exception. According to the local weather records, temperatures during March-August 1979 averaged 1.1° F (0.6° C) cooler than normal. Precipitation in February, March, and April exceeded 7 inches (18 cm) in each month, and 4.5 inches (11 cm) more than normal was received from March through August. Apparently, the English oaks are better adapted to a cooler, wetter growing season than the local white oaks are and, therefore, grew better that year. As a result, more English

oak families were taller than the best white oak family in 1979 than in the previous and following years, and fewer English oak families were shorter than the poorest white oak family.

In height ranking, three white oak families changed little with time, one family, got steadily worse, four were variable, and two families showed progressive improvement. Of the latter, one changed from a rank of 65 after the first year to 28 after 5 years, and the other improved in rank from 40 to 10. Thus, these families appear to be catching up with some of the faster growing English oak families.

Fifteen of the English oak families also showed little change in height ranking with time, 8 families were steady after the first year, and 17 were steady after the second year. On the other hand, 15 families were variable, 4 slowly fell behind, and 3 showed steady improvement. The latter three, however, all had below average growth. Certain families have consistently been among the best performers. For example, the family that was tallest at the time of planting is still the tallest after 5 years in the field. Six others have been among the top 10 percent of the families in from 3 to 5 of the 5 years. On the other hand, some families have been con sistently poor performers. Two families, for example, were among the poorest 10 percent of the families in all 5 years, two families were in that group in 4 years, and three families were in it in 3 of 5 years.

CONCLUSION

Only two English oak families in our study were at least 45 percent taller than the best white oak family and thus showed as much superiority as that reported for 13-year-old trees in southern Michigan (Wright et al, 1973). The high proportion of poor performers reduced the difference in average height after 5 years in the field to a nonsignificant 7 percent. English oak is clearly an extremely variable species and has the potential for fast growth, but testing is required to identify the best families. On the other hand, the few white oak families included in our study did not allow for an adequate test of white oak. When we test more white oak families, we might find some that grow as well or better than the best English oak. Our unit at Carbon dale, Illinois, has just begun such a test.

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