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Variability of Quercus macrocarpa Michx. in an eastern Nebraska provenance study[1])

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Summary

A provenance plantation of *Quercus macrocarpa* Michx. was established in eastern Nebraska during 1966. Morphological, phenological, and acorn characteristics were studied to determine the effect of provenance or variability.

Variation among provenances was discontinuous. Height growth maximized with trees originating 100 miles south of the plantation at 40 degrees north latitude. Correlation of juvenile-mature growth rates was high based on performance at 11 years. Between and within source variation was apparent in growth and acorn characteristics. Phenological information indicates that natural crossing among provenances over a wide geographic area would be possible. Fast growing trees were the last to drop their leaves in the fall.

Key words: Bur oak, *Quercus macrocarpa*, genetic variation, provenance test, phenology.

Zusammenfassung

Im Jahr 1966 wurde ein Provenienzversuch mit *Quercus macrocarpa* Michx. in Ostnebraska angelegt. Viele morphologische, phänologische und Eichelmerkmale wurden untersucht, um den Einfluß der Herkunft auf die Variabilität zu bestimmen.

Die Variation zwischen den Herkünften war diskontinuierlich. Das Höhenwachstum erreichte bei Bäumen aus Herkunftsgebieten 100 Meilen südlich des Prüfortes, bei 40 Grad nördlicher Breite, ein Maximum. Enge Jugend-Alters-Korrelationen über den Wachstumsgang konnten für das Verhalten im Alter von 11 Jahren nachgewiesen werden. Die Variation im Wachstum sowie in anderen Merkmalen war sowohl zwischen als auch innerhalb der Herkünfte offensichtlich. Natürliche Kreuzung zwischen Herkünften über ein weites geographisches Gebiet erscheint möglich. Schnellwüchsige Bäume warfen im Herbst ihre Blätter als letzte ab.

Introduction

Bur oak, *Quercus macrocarpa* Michx., is native in the north central United States and southern Canada *(Figure 1)*. It is found in scattered natural stands throughout much of the Great Plains Region where it is adapted to dry sites and competes well with prairie vegetation. Bur oak has been harvested in Nebraska for firewood, lumber, posts, and barrel staves. It is also valuable in protection and ornamental plantings.

Past research has shown differences among provenances of bur oak in response to various day lengths. Vaartja (1961) found small differences in reaction to length of photoperiod between Manitoba and Nebraska sources. He concluded that bur oak was less responsive to photoperiod than other tree species. However, Read and Bagley (1967) found that bur oak seedlings of Nebraska origin grew significantly taller under continuous light than under normal growing season daylengths. Long (1965) discovered that bur oak seedlings of northern sources produced shorter flushes of growth with less time between flushes than seedlings of southern sources. Long also found that the size of bur oak acorns decreases from east to west and south to north throughout the natural range of the species.

Santamour and Schreiner (1961) recorded differences in height and date of leaf coloration among bur oak seedlings of different origin growing in a nursery. After three growing seasons seedlings of South Dakota origin were 65 percent of the height of seedlings originating from Kansas. Leaves of trees of northern origin colored earlier in the fall than those of southern origin.

Acorns for this study were collected from natural stands of bur oak trees throughout their range with the most intensive sampling in the Great Plains Region *(Figure 1)*. Seedlings and seed were planted on the University of Nebraska Field Laboratory near Mead in 1966. This report evaluates the growth of these trees during the first eleven years and interprets variation in morphological and phenological characteristics.

Methods

Acorns were collected from one to five trees in fifty native stands during the years 1963 through 1965 in cooperation with the Soil Conservation Service and Agricultural Experiment Stations. The plantation was established during

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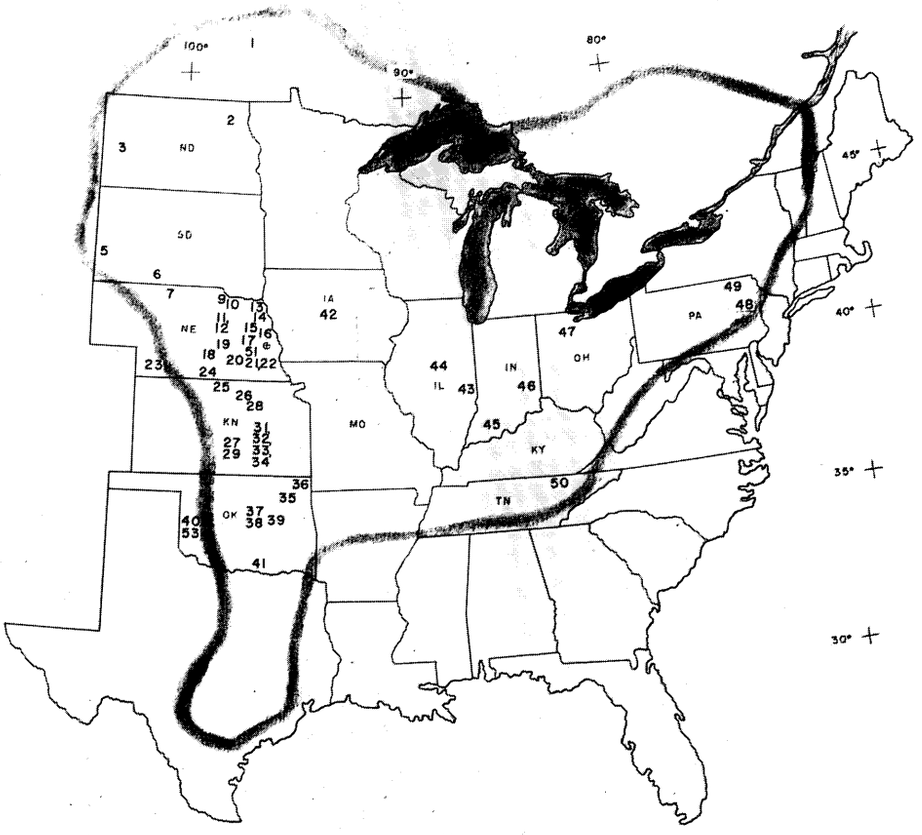

Figure 1. — Natural range of *Quercus macrocarpa* Michx. with seed collection locations. The provenance test plantation near Mead in east central Nebraska is indicated by circle.

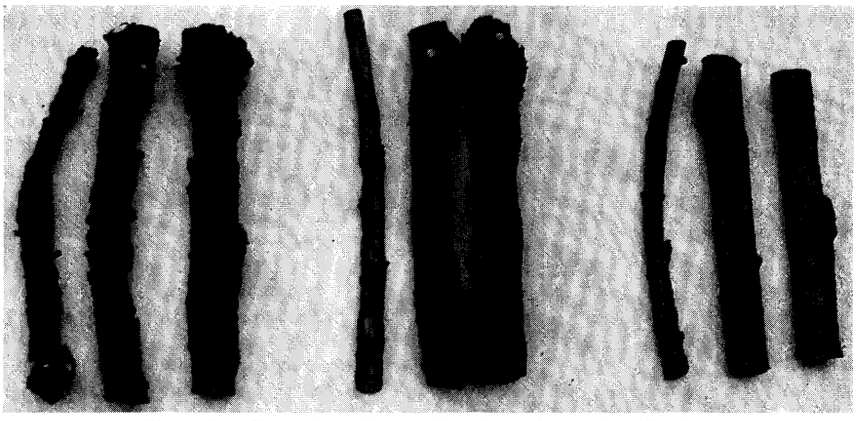

Figure 2. — Examples of twigs of each roughness classification. Left to right: corky, rough, and smooth.

April 1966 near Mead using seedlings from greenhouse studies supplemented by direct seeding of acorns. Twelve replications of each provenance were planted in single tree plots in a randomized complete block design. Unequal replication caused by 40 to 50 percent survival for most provenances prompted change to a completely randomized analysis of variance which confounded block and tree within provenance variation. Missing plots were replanted with local seed in 1969 and 1970 to reduce competition differences among the remaining trees. Fisher's protected LSD procedure was used to determine provenance differences (Chew, 1976). Regression analysis using provenances originating near a longitude of 97° tested for latitudinal variation.

Total height, diameter, and bark thickness were measured. Twig bark roughness was estimated using the twigs illustrated in *Figure 2* as a guide. Percentage of leaf drop was estimated on October 17, 1975. During the fall of 1977 the date of drop of 75 percent or more of the leaves was recorded. The dates of flush of leaves and staminate blowers were recorded during the spring of 1978.

Acorns collected from all trees were pooled by provenance. Random samples of 10 acorns from each provenance producing seed in 1977 were weighed and measured. Acorn length and diameter without cup and cup depth and thickness were recorded. Percentage of acorn length covered by the cup was calculated. Acorns of the original collection

from natural stands were compared with acorns produced by the same provenance in the test plantation.

Results

Survival above 60 percent was obtained for provenances 31 and 27 of Kansas, 13 of Nebraska and 2 of North Dakota. Provenance 1 of Canada was represented by five trees. Pennsylvania provenance 49 had one surviving tree which was the tallest in the plantation at age 11 years.

Height growth at nine years was found to maximize at 40° north latitude or approximately 100 miles south of the Mead plantation *(Figure 3)*. Twenty-two provenances, mostly from Nebraska and Kansas, averaged over 5.1 meters in height and 10.5 centimeters DBH at age 11 *(Figure 4)*.

Variation in average height of trees of selected provenances from the Great Plains Region ranged from about 4 meters for trees of South Dakota origin to nearly 6 meters for Nebraska trees *(Figure 5)*. Plantation trees of Tennessee and Pennsylvania origin were similar in height to the Nebraska trees *(Figure 6)*. Trees in the plantation established by direct seeding did not suffer any height disadvantage in comparison with those established by transplanting seedlings.

Crown injury in 1976 to one or more trees within 17 provenances from Canada to Oklahoma reduced their live height *(Figure 7)*. This accounts for the greatly decreased height of provenance 40, Canute, Oklahoma, which had dieback on three of five trees in 1977. Other provenances showing large decreases in rate of growth include another from Oklahoma and an Iowa source *(Figures 5* and *6)*.

Diameter and bark thickness were closely related to height *(Table 1)*. Twig bark roughness did not show prove-

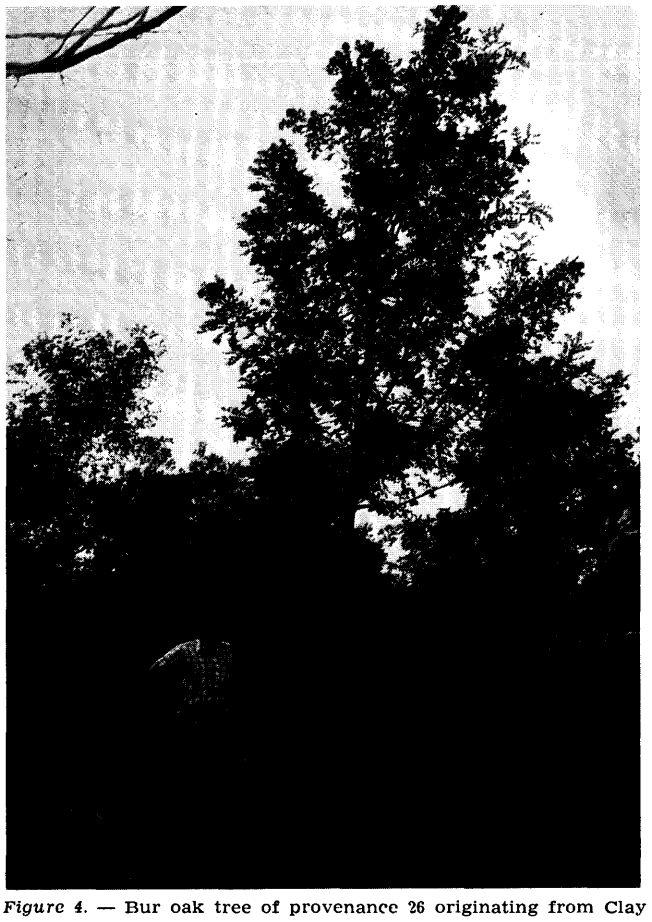

Figure 4. — Bur oak tree of provenance 26 originating from Clay Center, Kansas.

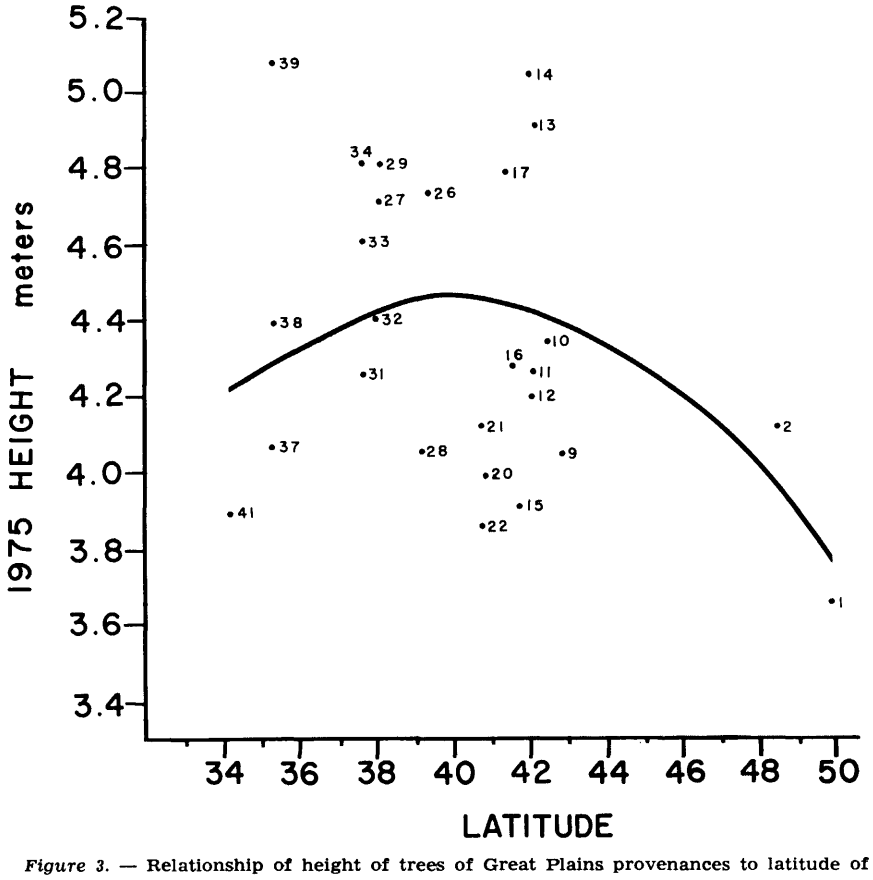

Figure 3. — Relationship of height of trees of Great Plains provenances to latitude of origin at age 9 years. Regression line is significant at $\alpha = .10$.

nance differences and was not associated with any other characteristic. There was no difference in growth between direct seeded and planted trees.

Date of leaf fall was variable among provenances with little regard to latitude of origin. Leaf drop sequence for each provenance was similar in 1975 and 1977 ($r = 0.64$). The correlation was low between height and date of leaf drop. A comparison of diameter (DBH) and leaf drop, however, showed that 10 of the 17 provenances with the smallest trees dropped their leaves early and 10 of the 16 provenances with the largest diameter were the latest to drop their leaves.

Data of leaf and staminate flower flush varied greatly from tree to tree, masking provenance variation. There was no correlation among the phenological and morphological characteristics studied.

Acorns produced at the Mead plantation of provenances originating between 40° and 42° latitude averaged larger than those from latitudes to the north and south. All acorn characteristics were correlated to acorn diameter ($r > 0.60$). Acorn diameter was the most consistent characteristic studied, varying only slightly from tree to tree within a provenance (C.V. = 11%).

Trees from provenances north of the Mead plantation produced acorns which were generally larger in diameter than those in the original collection from the parents. Acorns from southern trees tended to be smaller at Mead than from the original stands. In fact many trees of southern provenances produced smaller acorns than Nebraska trees at Mead even though they were larger in the original seed collection. Percentage of acorn covered by the cup and acorn cup thickness also showed differences between those in the original stands. Latitude of origin had no effect provenance collections. Sixteen of 22 sources in the 1966 plantation produced acorns with cups covering a larger portion of the acorns than those from the original stand. Plantation trees of Great Plains Region origin with deeper cups than those of the parent trees originated at about the same latitude or south of the Mead plantation. Ten of 21 plantation provenances produced thicker acorn cups than those in the original stands. Latitude of origin had no effect on cup thickness.

Discussion

Bur oak stands in the Great Plains Region of the United States are often scattered remnants of only a few trees. Therefore, the number of trees available to provide seed for this experiment was limited in some areas. Furthermore, the acorns collected from some stands were severely

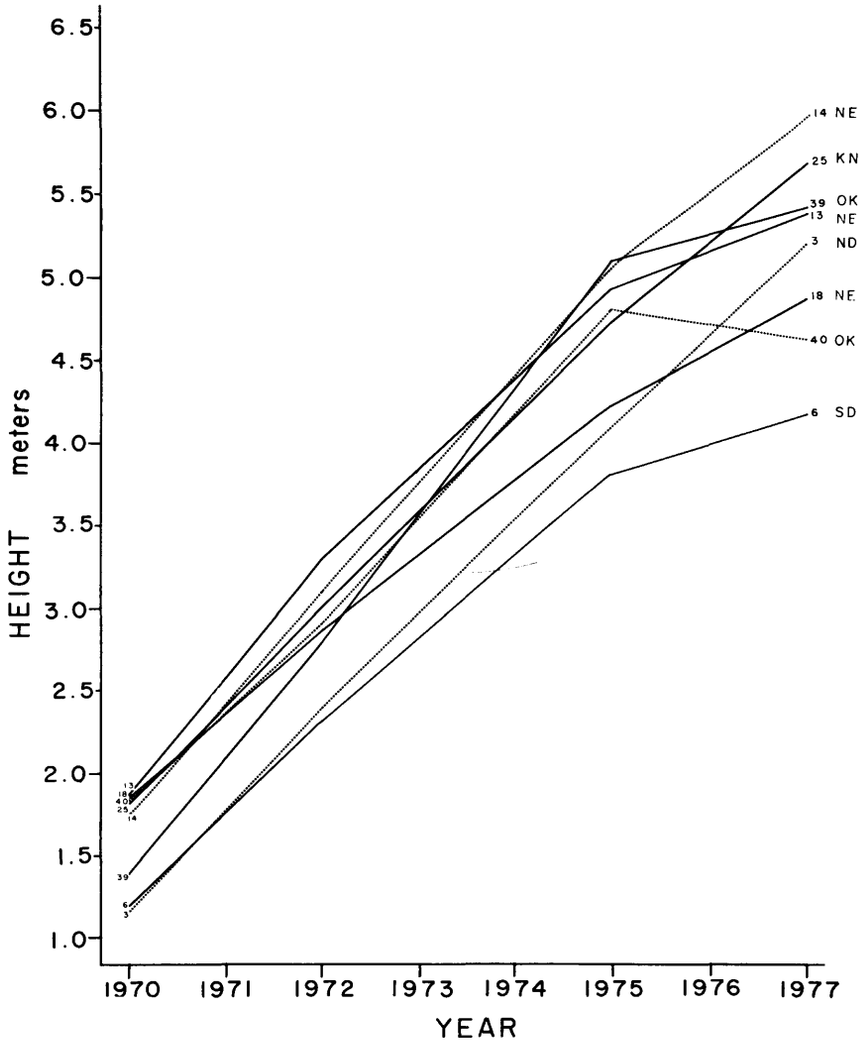

Figure 5. — Height growth of selected bur oak provenances of the Great Plains Region. Letters are abbreviations for state of origin.

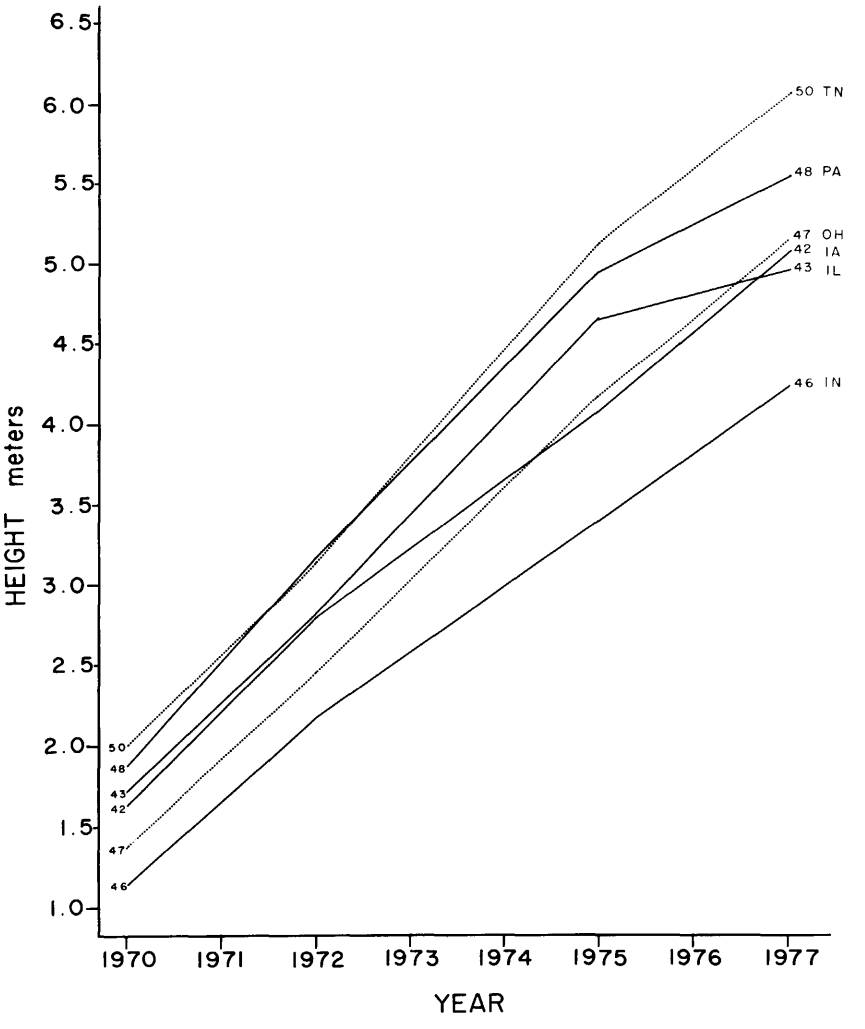

Figure 6. — Height growth of selected bur oak provenances of the Midwest and east. Letters are abbreviations for state of origin.

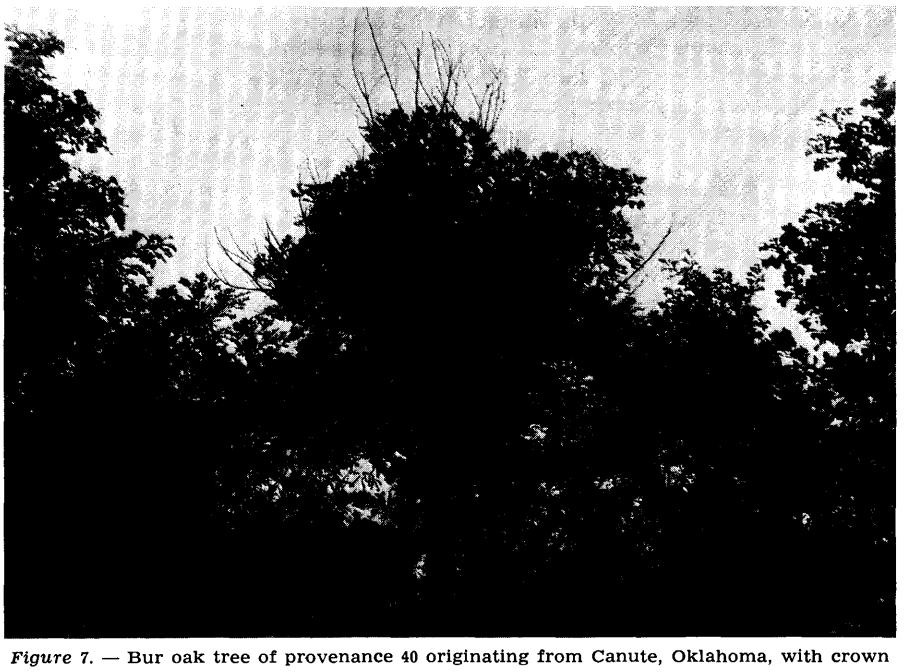

Figure 7. — Bur oak tree of provenance 40 originating from Canute, Oklahoma, with crown dieback.

Table 1. — Correlation coefficients for height, diameter and bark thickness at the Mead plantation.*)

	Ht. Age 4	Ht. Age 6	Ht. Age 9	Ht. Age 11	Dia. Age 9	Dia. Age 11	Bark Thick. Age 12
Height at Age 4	1	0.91	0.78	0.61	0.80	0.79	0.57
Height at Age 6		1	0.89	0.77	0.85	0.85	0.60
Height at Age 9			1	0.85	0.87	0.85	0.54
Height at Age 11				1	0.71	0.72	0.47
Diameter at Age 9					1	0.92	0.76
Diameter at Age 11						1	0.76
Bark thickness at Age 12							1

*) all correlations are significant at $\alpha = .10$.

infested with weevils (*Curculio* sp.). This and other causes of mortality conspired to reduce number of trees in the plantation and thereby complicated data analysis. We believe that surviving trees are adequate to provide us with useful information about inherent variability of the species and potential for selecting superior trees.

The results of this study and those of LONG (1965) and VAARTAJA (1961) are in agreement that growth varies among provenances of bur oak, but that evidence is strong that the relationship is not clinal. Trees of a southern provenance moved to a northern site will often respond to the longer photoperiod and grow faster than trees native to the site. SANTAMOUR and SCHREINER (1961) reported in their Pennsylvania nursery study that bur oak seedlings of Kansas origin grew much taller than those of South Dakota origin at three years of age. In another experiment they found that Illinois seedlings were taller than those from Minnesota. They did not have sufficient provenances to dertermine whether the variations were clinal or discontinuous.

Crown injury on part of the trees accounts for the low correlations of height to date of leaf drop. Since this injury did not significantly affect diameter growth, the relationship of diameter to date of leaf drop was similar to other research findings in that late leaf drop is associated with fast growth if injury does not occur. SANTAMOUR and SCHREINER (1961) found that leaves of the tallest sources in their nursery remained green later in the fall than those of the slow growing sources.

Cold temperatures might have been suspected as the factor causing dieback in 1976. Because of occurrence of this injury on one or more trees of several of provenances ranging from Canada to Oklahoma, however, it is believed that 2,5-D drift from adjacent cropland might have been responsible. The majority of the trees injured were located in the block nearest the cropland. Those with crown injury might have been in a stage of growth susceptible to chemical injury at the time of spraying.

High correlation among growth measurements at various ages indicates that growth tendencies of young trees are a reasonably reliable measure of mature performance. The overlapping dates of staminate flower flush among provenances indicates natural cross fertilization could occur among all trees in the plantation. Reduced spread in acorn size among provenances in the plantation as compared to those gathered from the parent trees indicates that environment is a significant factor in determining acorn size. It is doubtful that environment was responsible for lack of similarity of other acorn characteristics of progeny with parent trees, but there seems to be no logical reason for this disparity.

The discontinuous variability of bur oak among provenances might be due to man's activities. The stands from which the acorns were collected appeared to be natural. This species has seldom been planted by man for any purpose. However, acorns are easily collected and were a source of food for early inhabitants of North America. For instance, Indians and pioneers might have carried supplies of acorns for considerable distances. Either by design or accident, some of these could have been planted resulting in the introduction of new germ plasm to an area.

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