# GENOTYPIC VARIATION IN WHITE ASH--NURSERY RESULTS

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Abstract.--White ash trees grown from seed collected from 39 geographic areas were evaluated for height growth, leaf color, leaf angle, and date of leaf drop. After one year in the nursery, white ash from southern sources tended to be taller and hold their leaves longer in the fall than trees from northern sources. The taller trees also tended to be greener and have a wider leaf angle. Among-stand variation was generally greater than variation within stands or among ecotypes. Genetic variation for the four traits studied was generally low. Trees from this test have been outplanted at 23 locations throughout eastern United States for further study.

Additional keywords: Provenance, *Fraxinus americana*, ecotype, variance components, correlation.

White ash (*Fraxinus americana* L.) is an important hardwood species native to a wide geographic area in eastern United States and southern Canada. Over this wide natural range, climatic conditions vary from wet to dry and from mild to cold winters. We expect there will be a lot of genotypic variation in the species over this range. In early genetic research with white ash, Wright (1944) divided the species into three ecotypes: the northern ecotype included the area north of 41 degrees north latitude; the intermediate ecotype included the area between 39° N and 41° N; and the southern ecotype all the area south of 39° N. Ecotypes were distinguished on the basis of petiole color, leaf glossiness, type of root system, growth rate, winter hardiness, and ploidy level. Outplantings from Wright's early nursery studies were not established.

## METHODS

In 1973 and 1974 we collected white ash seed for a white ash provenance/progeny test. Seed was collected and sent to the North Central Forest Experiment Station's Forestry Sciences Laboratory at Carbondale, Illinois by cooperators from throughout the natural range. Seed was collected from 20 geographic areas in 1973 and another 35 areas in 1974. Seed that was collected in 1973 was stored dry at 34° F for a year. The 1973 seed and additional seed that arrived before November 15, 1974 was fall planted. The remainder was stratified and planted in the spring of 1975. This paper deals only with seedlings from the fall-sown seed.

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A randomized complete bock design was used in the nursery. Each of three blocks contained 228 plots or families from 39 stands (fig. 1). Most parent trees comprising a stand were located within a few miles of each other but separated by at least 500 feet. Seed from each family was broadcast on 1- x 4-foot plots in the nursery and covered with soil and sawdust. After germination in the spring, the trees were thinned to approximately a 2- x 2-inch spacing. In plots where germination was low, final spacing was wider than in the high germination plots.

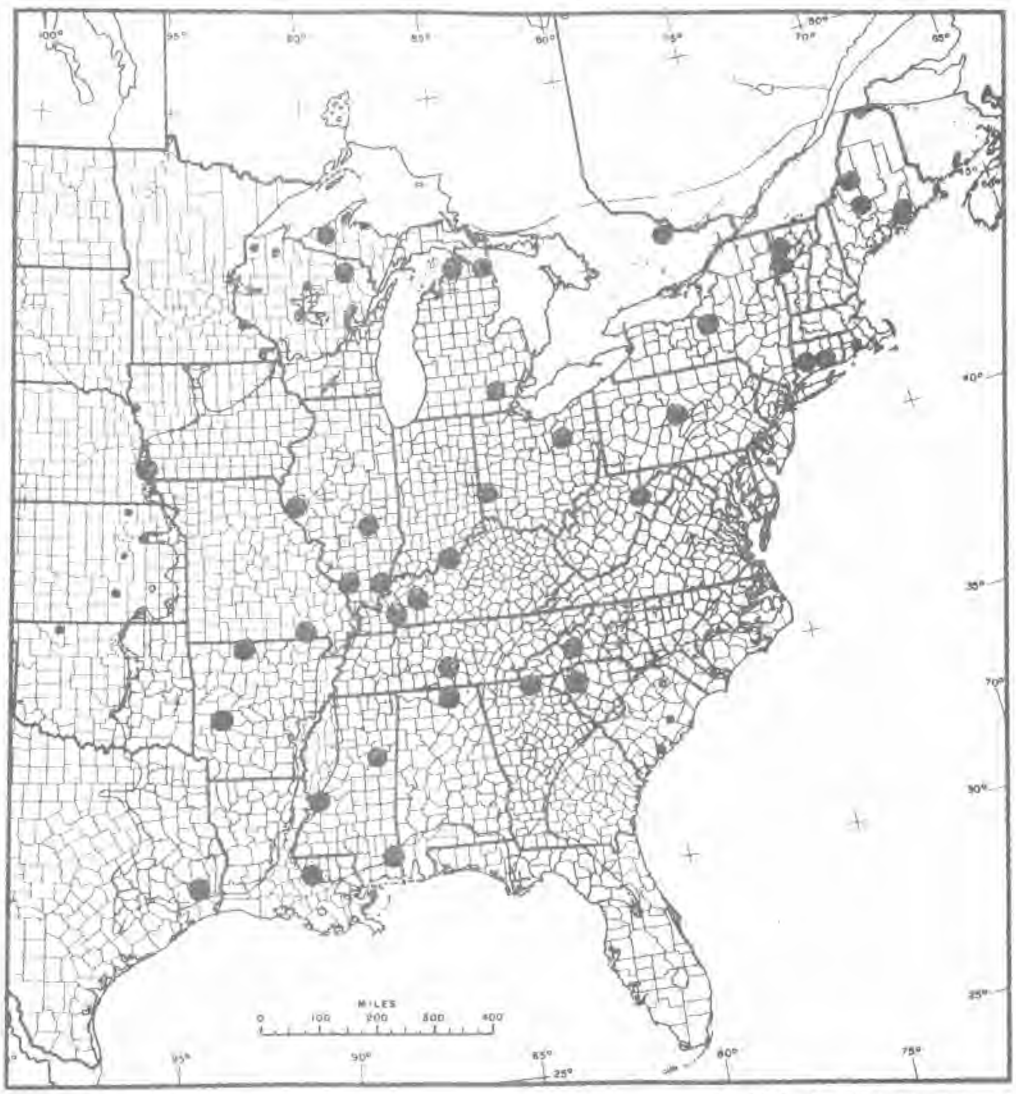


Figure 1.--Location of 39 stands included in the test.

In the nursery we collected data on height, leaf angle, leaf color, and date of leaf fall. Date of leaf fall was recorded as the date when all the leaves had fallen. Leaf angle was estimated by ranking from 1, for sharp angles, to 5 for angles 90° away from the vertical. Leaf color was ranked from 1 for yellow-green to 5 for dark green. For these traits, analysis of variance was used to test for differences among ecotypes, stands within ecotypes, and trees within stands. Ecotypes were delineated according to the previously explained zones proposed by Wright. Correlation coefficients were also determined for all combinations of traits and for the traits with latitude, longitude, and elevation of the parent tree.

## RESULTS

The seed generally germinated satisfactorily with variable but acceptable growth. Within the same plot the tallest and shortest trees were commonly 50% taller or shorter than the plot average,
The seed germinated first where the sawdust was the thinnest, presumably because the soil temperature was higher. On plots with less sawdust (confined to Block 1), the seedlings grew noticeably larger. Where the sawdust was heavy (2 inches or more in the spring), there was also a more noticeable yellow-green leaf color--probably due to nitrogen being tied up by the sawdust.

There were significant differences among trees/stands for leaf angle but not for leaf color, height, or date of leaf fall (table 1). If growth and phenological differences (date of leaf fall) among trees within stands cannot be distinguished, there seems to be little value in considering individual tree selection for these traits. Perhaps, however, if leaf angle and branch angle were correlated, gains could be made by selecting individuals for wide branch angles. Also, the tree/stand differences may become significant as the trees get larger and other traits (for example, pest resistance) may become important.

Table 1.--Level of significance for four traits for ecotypes, stands, and trees

| Source | Leaf color | Leaf angle | Leaf fall | Height |
|---|---|---|---|---|
| Ecotype | NS | NS | .01 | NS |
| Stand/ecotype | .01 | .01 | .01 | .01 |
| Tree/stand | NS | .01 | NS | NS |

Stand/ecotype differences were significant for all traits measured, so gains should be possible through stand selection. The population of stands/ecotypes was generally large. The southern ecotype included stands from 31  N to 39  N--a range of over 500 miles. This might be a greater range than included in any recommended seed collection zone, and so there might be more differences than in a tree improvement action program.

There were ecotypic differences for date of leaf fall but no other traits. This test does not rule out the possibility that there are white ash ecotypes for leaf angle, leaf color, height, or other traits. Perhaps ecotype lines drawn at latitudes other than 39° N and 41° N or at other boundaries would have produced different results.

Some differences among trees/stands, stands/ecotypes, and ecotypes were expected. Perhaps more important than these differences is the magnitude of the genetic variation of each component (table 2). Stand/ecotype component is the largest and trees/stand the smallest. The importance of determining the amount of genetic variation at the ecotype and stand levels before proceeding to individual tree selection programs is demonstrated by this example.

Table 2.-- Variance components by traits
(In percent)

| Source of variation | Leaf color | Leaf angle | Date of leaf fall | Height |
|---|---|---|---|---|
| Ecotype | 0 | 0 | 25 | 2 |
| Stand/ecotype | 18 | 11 | 20 | 30 |
| Tree/stand | 0 | 9 | 0 | 0 |
| Error | 82 | 80 | 55 | 68 |

There were several significant correlations between origin of sources and the various traits (table 3). Trees of southern origin tended to be larger and drop their leaves later than northern sources. Leaf drop from some of the far-southern sources did not occur until after a hard frost on November 14. Trees of western origin were greener and lost their leaves later than the eastern sources, although some of these correlations may be biased due to sampling. More of eastern sources were from the north and more of the western sources were from the south. Latitude and longitude of origin of sources were significantly correlated (r = 0.39).

Table 3.--Correlation coefficients and level of significance for traits and origin of seed sources

| | Latitude | Longitude | Elevation | Color | Angle | Leaf fall | Height |
|---|---|---|---|---|---|---|---|
| Latitude | - | | | | | | |
| Longitude | $.39^{.01}$ | - | | | | | |
| Elevation | NS | NS | - | | | | |
| Leaf color | NS | $.26^{.06}$ | $-.32^{.03}$ | - | | | |
| Leaf angle | NS | NS | $-.59^{.01}$ | $.53^{.01}$ | - | | |
| Leaf fall | $-.75^{.01}$ | $.25^{.07}$ | NS | NS | NS | - | |
| Height | $-.41^{.01}$ | NS | NS | $.33^{.01}$ | NS | $.41^{.01}$ | - |

Trees from lower elevation sources tended to be greener and have a wider leaf angle than trees from higher elevation sources. If leaf angle is indicative of branch angle, this may be an important selection trait. Trees with wide branch angles are likely to be better self-pruners than those with acute angles, Height, leaf color, and leaf angle are correlated in a positive and desirable manner. The taller trees tended to be greener and have a wider leaf angle. The darker green color suggests that the trees have greater and/or more efficient uptake of nutrients, and/or that the trees continue to grow later into the fall. The leaf color evaluations were done in early September.

Trees from the tallest sources tended to be the last to drop their leaves. Although we did not determine the period of height growth, we observed in the nursery that the taller trees, primarily from Texas, Louisiana, and Mississippi, grew longer into the summer. Although trees from these sources still had green leaves at the time of a hard freeze (23° F) on November 14, they did not appear to be damaged by the cold.

## OUTPLANTINGS

Outplantings of white ash from trees in this study have been established at 23 locations throughout eastern United States. Families were kept separate in the outplantings. At six outplantings most of the families included are common to the other five locations. At the 18 other locations, the families are primarily from the outplanting region. There are from 1 to 5 families per stand included at each location. Where there are families common to several locations, family x location interaction can be computed. As we get data from these plantations, information pertinent to developing tree improvement programs for white ash will be made available.

## LITERATURE CITED

Wright, Jonathan W. 1944. Genotypic variation in white ash. J. For. 42: 489-495.