PRELIMINARY RESULTS FROM GENETIC STUDIES OF RED MAPLE

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Red maple *(Acer rubrum* L.) has a natural range from Nova Scotia through Quebec and Ontario to Minnesota and southward deeply into Texas and Florida. The climatic extremes represented and the geographic area encompassed have provided opportunities for genetic differentiation within this species (Perry and Wu, 1960).

As a basis of our program for genetic improvement of maple for use in urban areas, we began a provenance study early in 1971. We are particularly interested in measuring and using genetic variation in the following traits: (1) adaptability or tolerance to stress conditions such as drought and air pollution; (2) growth rate; (3) *Verticillium* wilt resistance; (4) winter hardiness; (5) form and size of root system ; and (6) foliar coloration.

My purpose in this paper is to present initial results from studies of growth and coloration, and to summarize briefly the results from other experiments using seedlings of red maple. These studies are only indications of the variability we expect to find after outplanting the seedlings in various city and forest locations.

GROWTH AND COLORATION

Materials and Methods

From March to late June, 1971, fruits were collected from more than 60 locations throughout the range of red maple. Many cooperators in the United States and Canada assisted in assembling the ,material. In most geographic locations, seeds were collected from at least three mother trees. On arrival, each lot of half-sib seed was given an accession number to maintain identity of parent trees within areas. Seeds were then placed in cold storage or subjected to stratification, depending on future use.

Greenhouse and nursery studies: On November 3 and 4, 1971, seed representing 21 geographic areas were planted in three randomized blocks at the State Nursery, Marietta, Ohio. On March 8, 9, and 10, 1972, stratified seed from 168 half-sib families were planted in a peat: perlite: soil (2:2:1) mix in four randomized blocks in the greenhouse at Delaware, Ohio. On May 22, seedlings growing at Delaware were removed from the greenhouse and transplanted to nursery beds; the randomized block design used in the greenhouse was retained in the nursery beds.

Heights of the seedlings at Marietta were measured on May 10 and July 19, 1972, and at Delaware on April 18 and July 20, 1972. Concurrently with height measurements, coloration of leaves was estimated on each seedling, using a visual index of 0 (green) to 5.0 (red), corresponding approximately to 10 GY 5/2 and 5.0 R 4/4 on the Munsell color system (Anonymous, 1969).

Growth-chamber study: To compare growth differences among half-sib families from Alabama, Mississippi, Maine, and Minnesota, 25 seedlings from each family were grown under greenhouse conditions for six weeks in 4" quart pots. They were then transferred to a Sherer-Gillett growth chamber, where they were kept under a 16-hr. photoperiod (1,800 ft-c) at 77° F., and 70° F. in dark, for nine weeks. Relative humidity ranged from 40 to 60 percent. Height growth was measured weekly. Seedlings to be placed in the growth chamber were chosen so that the average beginning heights among families were not significantly different.

Results and Discussion

Greenhouse and nursery studies: Analyses of variance showed highly significant differences in total height at Delaware (Table 1) and at Marietta (Table 2), on all dates of measurement. Block effects on height growth were not significant at either location. There was not a significant difference among fast- and slow-growing sources either in speed of germination or in seed weight, two factors that otherwise would have partly accounted for the superiority of some seedlings over others. After about five months of growth in the greenhouse and nursery beds at Delaware, the tallest families were from southern States, and the shortest families were from northern Wisconsin, Minnesota, and Canada (Table 1). Superior growth rate of southern families or sources has also been shown in other widespread species (Wright, 1962). It is important to emphasize, however, that not ***all*** southern families were fast-growing; and not ***all*** northern families were slow-

growing. A nested analysis of variance, for example, revealed not only highly significant differences among geographic areas, but also among families within each area. Disregarding block effects, which were nonsignificant, the total,, variance attributable to geographic areas, families with areas, and seedlings within families was 23, 14, and 63 percent, respectively.

Table 1. Tallest and shortest of 128 half-sib families of red maple on 7/20/72 at Delaware, Ohio

Accession No.	Family	Average height (cm.) [a] 7/20/72	4/18/72
TALLEST:			
111 A	Greensboro, Ga.	20.4	8.1
100 A	Gainesville, Fla.	19.7	6.2
106 B	State College, Miss.	18.3	5.6
118 A	Harriman, Tenn.	17.7	7.4
110 A	Opelika, Ala.	17.1	7.1
117 A	Berea, Ky.	14.3	6.7
SHORTEST:			
166 B	Quebec	5.2	4.1
165 F	St. John's, Nfld.	5.4	4.7
165 A	St. John's, Nfld.	5.6	4.3
145 B	Rhinelander, Wisc.	5.7	5.4
145 D	Rhinelander, Wisc.	5.9	5.2
157 C	Ely, Minn.	5.9	4.8

[a] Each value is an average of 40 seedlings. Seed was planted on March 8, 1972.

Unfortunately, none of the seed from the southern sources—Florida, Georgia, Mississippi, Tennessee, and North and South Carolina—germinated at the Marietta nursery in 1971. Of the seedlings that did germinate, the fastest-growing were from Missouri, Ohio, and West Virginia. In contrast, the slowest-growing families represented northernmost habitats: Ely, Minnesota; St. John's, Newfoundland; and Fredericton, New Brunswick. The results corroborated some of our findings at Delaware; generally the slowest-growing seedlings were from northern locations, but considerable variation in height growth occurred among half-sib families from the same general geographic area.

Highly significant differences in leaf coloration were apparent among families at both Marietta (Table 2) and Delaware (Table 3) on both observation dates. Developmental changes resulted in more reddish leaves in April and May than in July. Ontogenetic factors may sometimes prevent reliable estimates of leaf color (Grime, 1961). However, we found fairly high repeatability between color estimates made on May 10 and those made on July 19 for 24 families growing at Marietta; the correlation coefficient (0.6109) was highly signficant. Considerable genetic variability within species of anthocyanin production has been demonstrated (Siegelmann and Hendricks, 1957). Complementary genes have been shown to be responsible for much of this variation (Reddy and Coe, 1962).

Table 2. Summary of analyses of variance of height and leaf coloration of red maple half-sib families growing at a Marietta, Ohio, nursery [a]

Source of variation	d.f.	Variance ratio (F) Height 5/10/72	Height 7/19/72	Coloration 5/10/72	Coloration 7/19/72
Families	23	2.214*	3.700**	2.867**	2.650**
Blocks	2	0.186	3.510	2.408	4.100*
Error	46				

[a] Analyses were completed using means of values from 10 seedlings/block.

* Significant at the 0.05 probability level.

** Significant at the 0.01 probability level.

Table 3. Summary of analyses of variance of leaf coloration of red maple half-sib families growing at Delaware, Ohio [a]

Source of variation	d.f.	Variance ratio (F) 4/18/72	7/20/72
Families	127	2.523**	3.850*
Blocks	3	1.391	2.290
Error	381		

[a] Analysis was completed using means of values from 10 seedlings/block.

* Significant at the 0.05 probability level.
** Significant at the 0.01 probability level.

A nested analysis of variance of 25 areas; three families/area; and 12 seedlings/family at Delaware showed significant differences among geographic areas (8 percent of total variance) and highly significant differences among families within areas (13 percent of the total variance). With block effects disregarded, variation of seedling color within families was 79 percent of the total variance. The families showing the most reddish foliage at Delaware were from Brownstown, Indiana, and Ely, Minnesota. The families that expressed the least reddish foliage at both Delaware and Marietta were from St. John's, Newfoundland.

Growth-chamber study: The superior growth of two Alabama and Mississippi families, compared to those from Maine and Minnesota, was evident throughout a nine-week experiment in the growth chamber (Figure 1). The Ely, Minnesota, seedlings showed the slowest

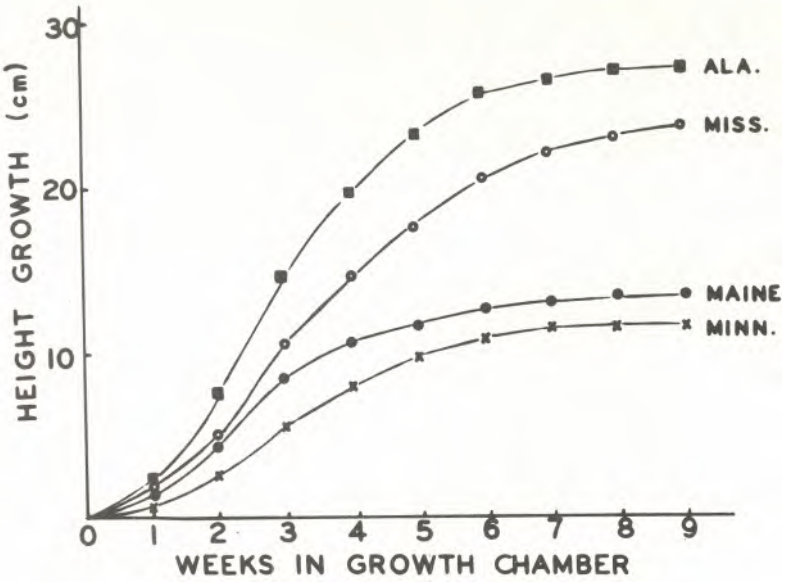

Figure 1. Height growth of four half-sib families of red maple in growth chamber: 1,800 ft-c, 16-hr photoperiod at 77°F; 70°F in dark; 40-60% relative humidity. Points represent average of height of 25 seedlings in each family. Average beginning height of all families was 10.2 cm.

growth rate; several seedlings stopped growing after only a week in the growth chamber. In contrast, all of the Alabama and Mississippi seedlings grew rapidly during the first seven weeks of the study (Figure 1). Perry (1962) demonstrated racial variation in the day and night temperature requirements of red maple. It is quite probable, therefore, that growing conditions were not as close to optimum for growth of the Minnesota and Maine families as for the Alabama and Mississippi sources. It is important, also, to recognize that considerable variation among seedlings existed within each family. For example, not *all* Minnesota seedlings ceased growth after four weeks. Further studies are under way to determine environmental control of optimum growth patterns among different red maple families.

SUMMARY OF RESULTS FROM OTHER STUDIES

We have completed several other preliminary studies of variation among families in tolerance to drought and *Verticillium* wilt. We have demonstrated higher transpiration rates in families from wet or swamplike sites than in those families from dry, upland sites. In one experiment simulating severe water stress, the seedlings from the upland sources stopped growth; those from wet sites continued to grow, transpired heavily, and wilted much sooner than the upland families. At temporary and permanent wilt, the dry, upland seedlings showed lower water potentials than the wet-site seedlings.

Highly significant differences among families have also been found in tolerance to *Verticillium dahliae* Kleb., which causes *Verticillium* wilt. Illinois and Arkansas seedlings have shown the least, and Pennsylvania and Minnesota seedlings the most symptom development and growth reduction after inoculation. Several seedlings from the more tolerant families have survived two inoculations with less than 25 percent symptom development.

CONCLUSIONS

Initial results from half-sib progeny testing of red maple indicate promising levels of genetic variation in height growth, leaf coloration, drought tolerance, and *Verticillium* wilt resistance. In all these traits, significant variation occurred, not only among widely separated geographic areas, but also among parent trees within each area. A successful breeding and selection program in red maple for superiority in the characters measured will therefore probably use both clonal- and family-selection methods.

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