GENETIC VARIATION IN A GREEN ASH POPULATION OF THE GREAT PLAINS REGION

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Green ash *(Fraxinus pennsylvanica* March.) is native to the eastern United States and a large part of the Great Plains Region. This tree species is widely planted in shelterbelts, farmstead windbreaks and ornamental plantings. It will become more valuable for these purposes as superior populations are indentified and introduced.

Meuli and Shirley *(2)* found that drought resistance of three seedling populations of green ash was greatest in the source of most northwesterly origin and least in that of most southeasterly origin. Wright *(5)* recognized three ecotypes of the species among collections from the eastern part of the United States. He found differences in growth rate, spring and fall phenological characteristics and winter hardiness. Santamour (3) compared seedlings from single mother trees in a planting in Massachusetts. This study revealed that differences in height within some provenances were as significant as among provenances in the 13-year-old plantation. Kramer (1) and Vaataja *(5)* concluded that green ash was not responsive to changes in day length.

The Soil Conservation Service provided green ash planting stock from seven sources ranging from Oklahoma to North Dakota which was used to establish a plantation at Horning State Farm, at Plattsmouth, in 1961. Similar plantings were made at Mandan, North Dakota, Brookings, South Dakota, and Manhattan, Kansas. Results from these plantings have not been published.

The purpose of our experiment was to determine the extent of genetic variations occurring in populations of green ash of the Great Plains region. They were observed under controlled environments, in the nursery bed, and in field plantations.

MATERIALS AND METHODS

Seed for this study was collected by Soil Conservation Service personnel in 1967 and 1968 from native stands in seven states (Figure 1). Seed collection from the Horning State Farm Plantation was also included.

The influence of various combinations of temperature and photoperiod on the growth of the seedlings was investigated in growth chambers. Part of the seedlings were grown in four temperature-controlled chambers with a light source consisting of one red and seven cool white fluorescent bulbs and programmed at 24 ° C. for the light period and 16 ° C. for the dark period in both experiments. Another part of the seedlings was grown in the greenhouse and received sunlight for 8 hours and light from a 75-watt incandescent bulb for the balance of the light period. Temperature was variable depending upon out-of-door weather conditions.

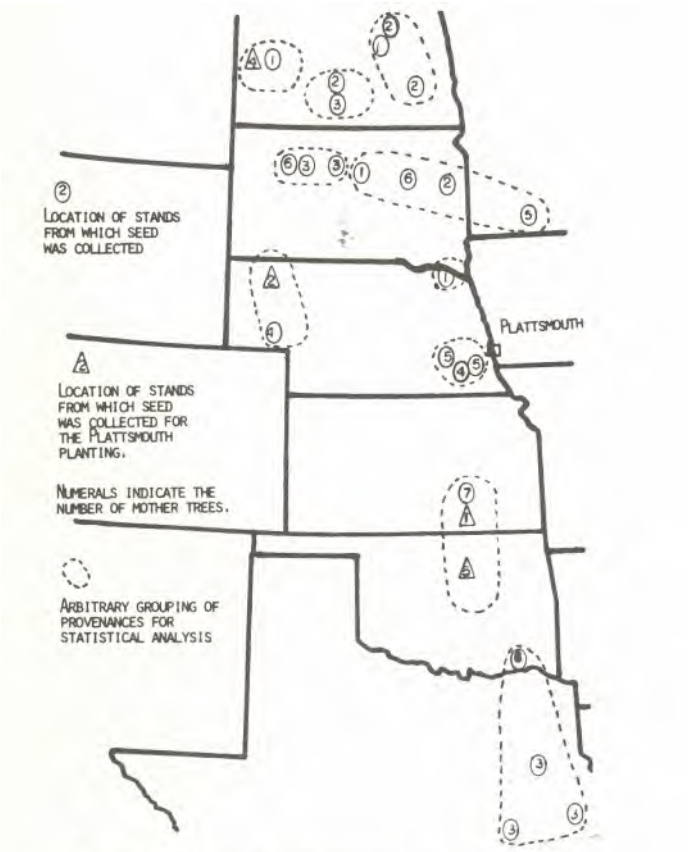

Figure 1. Green ash provenance locations

First experiment: Four light periods, 12, 13, 15, and 16.5 hours, were selected. The mean temperature was approximately 30 ° C. in the greenhouse chambers but it reached 45° C. on sunny days.

Seed collected from individual trees in the same county were mixed and planted in 5-inch pots and placed in the growth chambers. Seedlings were thinned to four per pot after germination. Seedling height was measured once weekly until cessation of growth.

Second experiment: The daylengths were 12, 14, 16, and 24 hours. The mean temperature in the greenhouse during the day was 27 -1- 4 ° C. and 16.112 ° C. at night. Four seedlings from a single parent tree from a given collection area were transplanted to each pot. When the seedlings started to flush, two pots of each source were moved into each growth chamber. Seedlings were measured as in experiment one.

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Nursery experiment: The nursery experiments were located in Lincoln. Four replications of 112 individual tree sources were planted in a randomized block design. Twenty-three sources did not produce adequate seedling numbers and were excluded. Height was measured at monthly intervals from June 23 to September 23 with a final measurement on October 6. Phenological observations were made on October 27, 1970. Observations were terminated after a hard freeze October 31.

Field experiment: Seedlings were lifted in the spring of 1971 and planted in the field at Lincoln. The planting consisted of progenies from 109 parent trees in 1-tree plots replicated six times in a randomized complete block design. Weekly observations were made to determine the date of leaf-bud break. Tree height was recorded at monthly intervals from April 27 to August 6. Biweekly measurements were then made until September 13. Leaf color and drop were recorded weekly from October 18 to November 10. Plot mean was the unit used for statistical analysis.

RESULTS

Growth chambers experiment one: Plant height generally increased with the increase of day length. Seedlings originating from Kansas, Oklahoma, and Texas grew larger in the six weeks period than other sources. Plants derived from Minnesota seed grew faster than most plants originating from seed obtained from Nebraska northward.

The seedlings in the greenhouse chambers grew less than those in the temperature-controlled chambers. The effect of day length was not noticeable. Plant height response of the sources was similar to those in the temperature-controlled chambers.

In both sets of chambers the total number of days from germination to cessation of growth was significantly different among sources and highly correlated with the length of the average growing season of the native habitat of that source (r = 0.89).

Growth chambers experiment two: The influence of daylength and seed origin on height growth was highly significant in both sets of chambers (Table 1). No photoperiod-seed source interaction was observed. Plant height was proportionately greater in the treatments with longer daylengths. Seedlings derived from seed collected from Kansas and southward grew faster than those derived from northern seed sources. Progeny of a tree from Watonwan, Minnesota (1050) grew slightly less than the progeny from a tree near Seward, Nebraska, in the temperature-controlled chambers, but grew faster than plants from all other Nebraska and northern sources in the other set of chambers. Long daylength or continuous illumination did not prolong the growing period.

Nursery experiment: Seedling emergence began about one week after planting. Seed from northern sources generally germinated earlier than from southern ones. Seedlings from several sources in North Dakota and Nebraska maintained their early growth advantage and were taller than most of those from the southern sources at the end of the season. Trees of the southern states

Table 1. Analysis of variance of height increment of green ash seedlings grown in the growth chambers in experiment 2

Source of variation	*Temperature controlled*		*No temperature control*	
	DF	MS	DF	MS
Total	63		63	
Photoperiod (pr)	3	107.16**	3	67.24**
Seed Source (s)	7	12.80**	7	19.16**
Pr x S	21	3.46	21	2.68
Error	32	4.84	32	2.24

** Significant at 0.01 level

grew more slowly at first but equalled or surpassed at seasons end some of those which grew at a faster rate early in the season. Individual parent trees whose progenies were outstanding in total height growth are shown in Table 2. Most seedlings which suffered winter injury were of Oklahoma and Texas origin (Table 3).

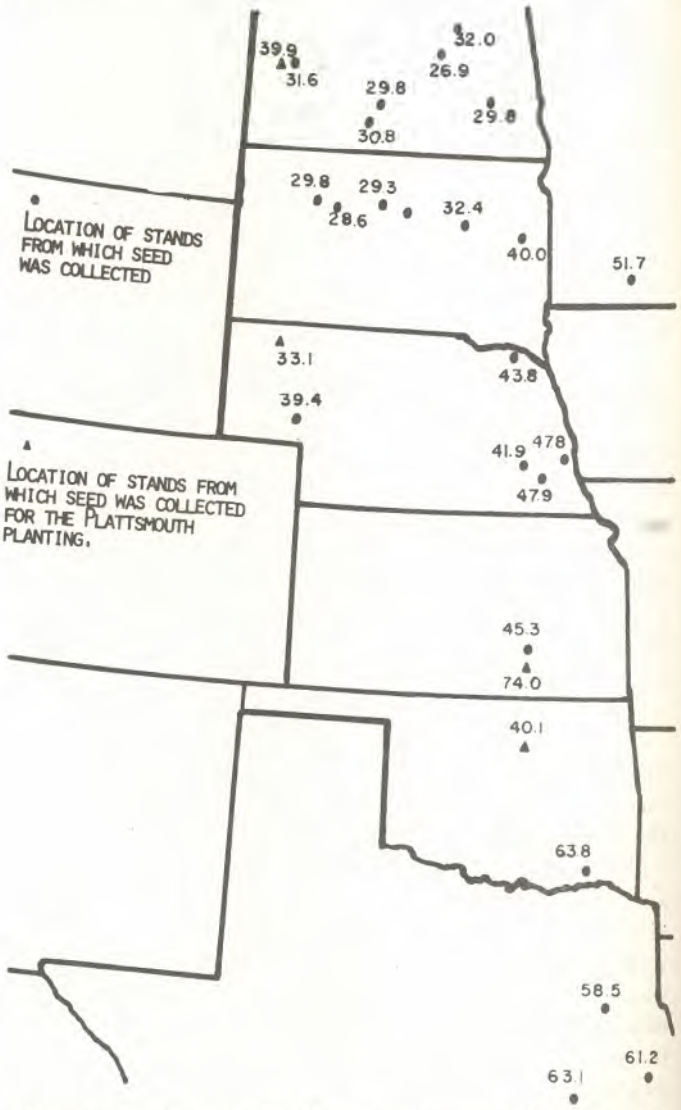

Figure 2. Average height growth cm. of green ash after the first year in the field planting. Each amount is the average growth for progeny of one to ten trees growing in the immediate area.

Field study: The growth of trees from southern Oklahoma and Texas at the end of one season in the field was about twice that of North and South Dakota sources (Figure 2). These southern seedlings broke dormancy about 2 weeks later than those of northern origin but made substantial growth during August whereas those from North and South Dakota had nearly stopped growing about one month earlier.

Significant variation occurred in plant height of populations derived from origins within a geographic area, but it was not as great as that among areas. Nine of the 10 fastest growing trees were from Texas and Oklahoma (Table 2). It was interesting to note that the fifth-ranked tree source (1050) was of Minnesota origin. In fact progenies of this specific origin performed better than most of those from other northern and central states.

Table 2. The ten origins of green ash making the greatest height growth in one growing season+

Parent tree	Nursery Bed *Origin county, state*	*Mean height growth* (cm.)
1180	Cedar, Nebr.	57.7
1520	Butler, Kan.	53.8
1420	Montgomery, Tex.	52.2
1300	Choctaw, Okla.	49.5
1320	Choctaw, Okla.	48.7
1350	Choctaw, Okla.	47.0
1200	Cedar, Nebr.	45.8
2260	Cass, Nebr.	43.6
1760	Dunn, N. D.	43.2
1210	Cass, Nebr.	41.1
	First Year in the Field Planting	
1500	Tyler, Tex.	93.5
1320	Choctaw, Okla.	89.3
1310	Choctaw, Okla.	81.9
1340	Choctaw, Okla.	81.6
1050	Watonman, Minn.	81.3
1420	Montgomery, Tex.	76.5
1330	Choctaw, Okla.	73.7
1430	Montgomery, Tex.	72.5
1998	Oklahoma, Okla.	69.1
1360	Choctaw, Okla.	66.1

+Average height growth of the experimental population in the nursery bed was 34.2 cm. Average height growth of the experimental population in the plantation was 39.6 cm.

Winter injury was detected on only those seedlings of Texas origin and on the progeny of one Minnesota origin (Table 3).

On April 26 more than one half of the seedlings from North and South Dakota and Nebraska broke dormancy. At this time the trees from Oklahoma and Texas seed sources were mostly dormant. On May 24 the trees were at various stages of growth activity, from barely breaking dormancy to leaves at about one-half full size.

Leaves of trees of northern origin changed color and dropped earlier than those of southern origin. On October 18, 25 to 50 percent of leaves of the seedlings from northern states were colored yellow while seedlings from Nebraska and Kansas were just starting to change color on this date. On November 10 all seedlings had dropped their leaves except those from Kansas, Oklahoma and Texas sources.

Table 3. Percentage of green ash sources with winter injury

Origin	*Nursery study 1970 - 1971*	*Field planting 1971 - 1972*
Texas	65	39
Oklahoma	77	0
Minnesota*	17	17
Kansas	7	0
Kansas**	17	0
Oklahoma**	37	0

*One extremely fast growing individual tree source from Minnesota. Five other slower growing individual tree sources from the same Minnesota county were not injured.

** Location of original sources (seed was collected from a provenance planting at Horning State Farm, Plattsmouth, Nebraska).

Progeny from the Plattsmouth provenance plantation generally responded in the same manner as those seedlings which originated directly from native stands. Those of Kansas and Oklahoma origin grew faster than those from North Dakota and Nebraska (Table 2). Date of dormancy break and leaf drop patterns were also similar.

DISCUSSION AND CONCLUSIONS

The tendency to faster growth by the southern progenies as observed in all experiments agreed with the results of other experiments *(2,5)*. The field plantation indicated a gradual change in amount of growth from north to south as a result of change in latitude of origin. Clinal variation was not as apparent in the growth chamber experiments. This was probably due to the smaller population sample in these studies. Also, the chamber environment probably did not allow the seedlings to express their full growth potential.

The southern seed sources may not have had the proper growing conditions in the nursery beds to allow them to overcome the disadvantage of late seed germination.

Considerable variation among individual tree sources within a geographic area was observed. In some cases the range in plant height of seedlings from the individual parent trees growing within a few miles of each other was as great as the total range of growth in a large geographic area. This appears to justify the

assertion that individual tree variation should be emphasized as well as provenance in the improvement of green ash (3).

The fact that the progeny of the Plattsmouth provenance plantation responded in the same manner as the seedlings collected from native stands of similar geographic origin indicated that natural crossing among different geographic sources planted side by side did not occur. Consequently, differences in anthesis dates among widely separated origins of green ash are great enough to allow collection of seed from a provenance plantation with genetic characteristics similar to the original population. Controlled hand pollination will be necessary to combine genes from different germplasm sources.

Measurements and observations of two other provenance studies which have been established in Nebraska, plus similar plantings in South and North Dakota and Kansas, will provide additional genetic information of this species.

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