NC-51 Provenance Research by the Wisconsin Agricultural Experiment Station

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The contributing project of the Wisconsin Agricultural Experiment Station to Regional Project NC-51 has reflected the diverse interests of staff members working in tree improvement. Two major facets of tree improvement have been represented, provenance investigations and studies on variation in susceptibility to diseases. The provenance investigations with two species will be discussed here.

Balsam Fir

The major involvement of the Wisconsin Station in provenance research centers on the initiation of studies of geographic variation in balsam fir, *Abies balsamea* (L.) Mill. Balsam fir constitutes a substantial portion of the softwood pulpwood used in the Lake States (18% in 1963; Horn, 1964) in addition to holding a considerable share of the Christmas tree market. *Abies fraseri* (Pursh) Poir. is also of interest as a species for Christmas trees.

As a primary objective, the fir studies are intended to examine the pattern of variation for a variety of morphological and physiological characteristics in collections of materials from much of the accessible species range. Breeding studies with crosses between diverse provenances and individuals constitute a secondary objective to follow as pollen and pistillate stroboli become available.

Acquisition of materials of balsam fir was begun in 1960 with cone and needle collections from 14 stands in the Lake States and Manitoba. Eighty additional collections were made in 1962, mostly by cooperators in Canada and New England. A few additional collections were received in 1963 and seed acquisition has now been completed with twelve additional collections this year. The provenances are represented by samples of from four to sixteen trees scattered over a few to several acres. Among the recent acquisitions of particular interest are seeds from eastern Alberta, from Newfoundland, and from one of the very few native, remnant stands in northeastern Iowa. Collections of seeds of *A. fraseri* have been less successful. Only two very small seed lots are now on hand.

Seed acquisition has presented no unusual problems although the general two-year cycle of seed production, the dehiscent nature of fir cones at maturity, and a very high incidence of damage by cone insects in several collections have caused difficulties. Cone collections were made either by chopping down the trees or by climbing to a stem diameter of about three inches and reaching from that point to break cone-bearing branches with a twelve-foot cone hook. Cones were air dried for two to four weeks and the seeds were extracted in a small seed mill.

The separation of filled and empty seeds in an air column was fairly satisfactory where more than a few hundred seeds were available. For most of the collections, cones were kept separate by trees and approximately equal amounts of seed from each tree were combined to make the sample. From each combined sample, a more sensitive discrimination between filled and empty seeds was made in 95% ethanol until 25 filled seeds were obtained. The 25 filled seeds were brought to an equilibrium moisture content in an atmosphere of 80% relative humidity and were then weighed to the nearest tenth milligram. Seed samples ranged in weight from 130 to 250 milligrams. Seed weights were generally higher in the eastern portion of the species range but no pattern of geographic variation was evident, possibly due to confounding effects of cone insects on seed weight. The seed weights will be used to examine possible influences of seed weight on early seedling growth.

In October, 1963, 97 seed collections were sown in row plots at the Trout Lake Forest Nursery. The Trout Lake Nursery, located in northern Wisconsin, was chosen because it lies within the natural range of balsam fir and because the average frost free season of 90 days should provide ample opportunity to test variation in spring frost susceptibility, a major problem in balsam fir planting in Wisconsin. Twenty-four seed collections were also sown in the Griffith Forest Nursery in central Wisconsin, to provide a measure of provenance-nursery interaction. The randomized, complete-block design was replicated four times. An estimated 2,500 seeds were sown in each

row. Germination in early May, 1964, was sufficient in 75 collections at Trout Lake to provide material for a nursery study of geographic variation. Rows in which stocking was particularly dense were thinned to a maximum density of about 6 seedlings per linear inch. High temperatures and/or lack of water in mid-July further reduced seedling density by 10 to 25%. The high seedling densities are being maintained at least until seedlings have a sufficient shoot to mutually shade each other. Balsam fir is reputed to be particularly sensitive to high temperatures. Lath shades have been over the beds and will not be removed until the start of the second growing season.

The seedlings now average about 25 millimeters tall. Differences between the collections during the first summer have not been sufficient to encourage measurement.

Seeds from 87 individual trees from nine stands in Manitoba, Michigan, Minnesota, and Wisconsin were also sown at Trout Lake in replicated row plots. Thirty-six collections from five stands have produced enough seedlings to provide estimates of within-stand variation.

In addition to the replicated row plantings for nursery studies, the seeds from each collection were sown in unreplicated plots to provide seedlings for out-planting in Wisconsin and for distribution to Michigan and Minnesota. An estimated 10,000 seeds were sown in an area of approximately six square feet. Where seedling densities are sufficiently high, a final density of 150 seedlings per square foot is planned for age three when the seedlings are to be lifted and outplanted.

Three outplanting sites ranging from loamy sand to clay loam have been chosen in Wisconsin. On the sandy site, a machine planting is planned, while on the heavier soils, planting will be by hand under a light overstory of aspen. The aspens will be poisoned one season before planting. Methods for successful field planting of balsam fir are apparently the subject of some controversy, although correspondence with Wisconsin planters indicates that no particular precautions are taken. A small machine planting of six open-pollinated progenies of balsam fir was made in central Wisconsin in 1964 as a test of our new planting machine. The site was open, abandoned agricultural land overlying sand and a high water table. As of early August, survival appeared to be well above 95%.

Along with the seeds of balsam fir, many collectors included cones and needle samples which were kept in a fixative solution. We are currently examining these materials to provide supplementary information on variation in balsam fir. Preliminary measurements suggest that stalk length of the bract may be the chief morphological characteristic underlying the bract exsertion which distinguishes variety *phanerolepis* from the species. The variety *phanerolepis* occurs in the northeastern portion of the species range, particularly at higher altitudes. Myers and Bormann (1963), sampling cone characters from trees in the Lake States and eastward, suggested that variation in the ratio of bract length to cone scale length is clinal and that the validity of the variety is questionable. The study by the Wisconsin Station is intended to further elucidate variation in floral morphology in balsam fir with samples from a wider range and to add information on variation in needle morphology. Substantial variation in numbers of stomata has been found in our materials from different portions of the range.

Japanese Larch

Another experiment of particular interest in Wisconsin is our planting of Japanese larch *(Larix leptolepis)* from a study initiated by Michigan State University. Twelve replicates of four-tree plots provide a test of relatively high precision for the six provenances growing on loamy sand in north-central Wisconsin.

Table 1 indicates seed origins and Table 2 summarizes measurements made after four growing seasons. For a species with such limited geographical distribution, the range of variation seems surprisingly large. The tallest seed source was nearly 20% taller than the average.

Variation was equally as large or larger in other characteristics. An estimate of terminal bud set on leaders in September, 1963 suggested major differences between provenances in the duration of shoot extension. The larches are characterized by a particularly long season of growth and may thus be subject to damage by autumn frost. In nursery data which included the same provenances as the Wisconsin planting, Genys (1960) noted differences between provenances in susceptibility to early frost. Unfortunately, there may be a relationship between total height and the duration of shoot elongation so that the tallest seed sources may continue to be subject to autumn frost damage. An estimate of spring frost damage in 1964 likewise indicated variation between seed sources, possibly attributable to variation in the time of flushing. The site on which this test is growing has an average annual frost-free period of 120 days. Additional tests in areas of Wisconsin where the frost-free season reaches 180 days should be established.

In several other characteristics, variation between provenances was also apparent. Provenance Schm.-9 is characterized by a distinctive habit which can be somewhat quantitatively expressed by the number of branchlets one inch long or longer on the current years terminal shoot. The manner in which the needles are held at a more acute angle on long shoots of Schm.-9 also adds to its particular appearance. In 1964, Schm.-9 further distinguished itself by producing staminate and pistillate stroboli.

The pattern of variation in these several characteristics generally showed little relationship to the variables of geographic origin. The exception was the correlation of total height and altitude of the seed origin; a highly significant correlation of +0.96. A highly significant correlation of +0.90 was calculated using data from the same seed sources planted in northeastern Iowa (Kepler

and Gatherum, 1964). Total height after three growing seasons in Iowa was highly significantly correlated with total height after four growing seasons in Wisconsin = +0.92).

On the basis of these analyses, at least for growing conditions similar to the test sites in Wisconsin and Iowa, seed collections of Japanese larch from stands within the range of 5,600 to 6,600 feet give the greatest early height growth. The influence of frost on early height growth may be a modifying factor in the success of Japanese larch plantings in regions with short frost-free seasons.

Table 1. Seed origins of Japanese larch planted in 1960 in north-central Wisconsin.

Provenance[1]	Latitude	Longitude	Elevation (feet)
Schm.—			
15	36°47′N.	139°32′E.	5600
4	35°36′	138°41′	4900
9	35°36′	138°19′	4800
12	35°27′	138°06′	6600
22	36°24′	137°41′	4600
24	35°54′	137°34′	4600

[1] Nmbers used are the same as in Schmalenbeck, Germany, whence the seed was originally distributed.

LITERATURE CITED

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Table 2. Summary of data on six provenances of Japanese larch after four growing seasons in north-central Wisconsin.

	Provenance		Height (feet)	Survival (trees per plot)	Terminal bud set on leader—9/9/63 (arcsin$\sqrt{\%}$)	Spring frost damage (score)[1]	Number of branchlets ($\sqrt{x+0.5}$)	Number of trees flowering	Number of strobili
Schm.–	15	1	4.9	3.8	69.4	2.8	2.69	0	0
	4	3	4.1	3.2	48.8	3.5	2.88	0	0
	9	4	3.9	3.4	82.9	1.3	0.97	8	42
	12	5	5.3	3.8	39.5	3.0	2.75	0	0
	22	6	4.1	2.2	63.2	3.2	2.66	0	0
	24	7	4.1	3.3	60.0	3.2	2.62	0	0
		F	4.8**[2]	7.1**	6.0**	26.2**	11.8**		
LSR[3]		.05	0.8	0.7	19.3	0.5	0.5		
LSR		.01	1.0	0.9	25.5	0.6	0.8		

[1] Measured 6/13/64. 0 = no damage, 4 = heavy damage on all trees.
[2] Means differ significantly at the probability level of 1%.
[3] Means which differ by more than the indicated approximate LSR (for 4 means) are significantly different at the probability level indicated (Duncan, 1955).