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New Trees
For
The North Central States

by
JONATHAN W. WRIGHT

OUR present forest trees are good. They are not perfect, though. They developed as the result of natural selection to fit various ecological niches in pre-white man forests. Our forest sites have changed and wild type trees are no longer in perfect equilibrium with their environment. Also, natural selection favored types which survived and reproduced best, not the types which would produce the best sawlogs or the best pulpwood.

There is every reason to believe that the tree breeder can accomplish as much improvement in trees as the corn breeder did in corn. The theoretical foundations of hybrid corn were laid in the 1880's. It was introduced as a practical farm crop in the 1920's and a decade later had almost pushed the older open-pollinated varieties off the market. As of 1961 the excess annual corn yields due to the advent of the hybrid varieties are more than sufficient to pay for all American plant and animal breeding work for all time.

The Time Element in Tree Breeding

When will these improved varieties of forest trees be available? A few have already been developed and could be made available to commercial forest nurseriesmen on two or three seasons' notice. The Shimek aspen hybrid (Populus alba L. XP. grandidentata Michx.) recently discovered in Iowa could be economically mass produced by seed next season. A recent provenance study of jack pine (Pinus banksiana Lamb.) furnishes good evidence that Lower Michigan origins are the fastest growing and that foresters in the southern part of the Upper Peninsula could advantageously order Lower Peninsula seed. The hybrid Japanese-European larch (Larix leptolepis Gord. X L. decidua Mill.) has excelled its parents in dozens of European tests and can be tentatively recommended in place of its parents in this country. Provenance trials of Scotch pine (Pinus sylvestris L.) have showed which geographic origins furnish the deep green, short-needled trees so desired by Christmas tree growers.

These examples are a small fraction of the improved varieties yet to come. Serious forest genetics in this region started only 6 years ago. The tempo of the work increased rapidly and nine experiment stations are now involved. It is their future results in which we are most interested.

It is possible to build a model showing that new tree varieties will come into being 30 times slower than new corn varieties because a tree generation is 30 times as long as a corn generation. It is possible also to build a model showing that new tree varieties can be developed as fast as new corn varieties. The truth is somewhere in between. I feel that a tree breeder can probably get his new products on the market at least half as fast as a corn breeder.

This feeling of optimism is based partly on the fossil record. It shows that evolution actually proceeded faster in long-lived elephants and horses than in many short-lived animals. The optimism is based partly on the fact that the tree breeder is working with wild, unimproved species. Some of these are so variable genetically that significant advances can come from rapid "cream-skimming" studies. And part of the optimism is based on the output of the most productive tree breeders of the past. For example, a few workers at Institute of Forest Genetics in California assembled a very large amount of information on species crossability patterns, growth of F1 hybrids, and mass production methods in the comparatively short space of 35 years. Their output would be a credit to any plant breeding agency.
One of the ways by which a tree breeder can keep pace with his counterpart on wheat or corn is to work on several species simultaneously. An experiment on jack pine may be started in 1961 and near completion in 1971. An experiment on Scotch pine may be started in 1962 and near completion in 1972. By this shotgun approach there need be only one time lag. By 1971 the breeder can be assured of a significant new result every year.

The study of the correlations between nursery and mature performance is another way of hastening the tree breeders' work. A Swedish worker recently found a strong correlation in growth from between old Scotch pine trees and their young seedling progeny. He can now use this correlation to establish the effectiveness of selection for growth form in young plantings.

The most unfortunate aspect of the long-term nature of forest genetics research is the tendency to excuse ourselves from precise experimental work. Many tests of species hybrids do not include the parents. Older provenance trials were not replicated. Grafted seed orchards are being established with no information on heritability. These poorly designed experiments are not shortcuts because their results do not bear close scrutiny. Well-designed experiments could be performed just as easily — sometimes more so.

**Today's and Tomorrow's Larches**

Today's larches in the Lake States are the native tamaracks (*Larix laricina (Du Roi) K. Koch*) of the swamps. They are not planted to any great extent because of the difficulties of swamp reforestation. Tomorrow's larches will probably be very fast growing hybrids adapted to upland soils. Whether there will be one new variety adaptable to the whole region or several new varieties, each adapted to a specific locality remains to be seen.

I have already mentioned hybrid Japanese-European larch as being available for planting if anybody wishes to make the artificial controlled pollinations, which are relatively easy. I would like to carry this hybrid back into its parents and forward into the future to show how the prototype hybrids now available can be improved.

The first hybrids of this combination arose as the result of natural crossing between Japanese larch trees and European larches planted on the Duke of Atholl's estate in Scotland. That was in 1907. By the 1930's the Danes were repeating the cross and establishing test plots. In every case the hybrids outgrew either parent. It was the same story when the Germans and English repeated the cross. The hybrids outgrew their parents.

The only hitch to this story is that the hybrids produced so far are of unknown parentage. The crosses should be repeated with selected parents of both species.

The stage is now being set for the production of improved hybrids 10 to 15 years hence. In 1960 a project known as NC-51, financed in part by a grant from the U.S. Department of Agriculture was undertaken cooperatively by most of the Agricultural Experiment Stations in the North Central region. The first official work on this project — undertaken before the funds were actually available — was the establishment of a series of 23 geographic origin tests of the Japanese parent in nine different states. Measurements made in the nursery before the trees were lifted showed that these origins differed from each other by as much as 20 percent in growth rate, as well as in winter hardiness and foliage color.

Similar geographic origin studies of the European parent will be established in 1963 or 1964. Evidence from past European studies indicates that here, too, some origins will exceed others by 40 percent in growth rate and that there will be large differences in form.

By 1970 or 1975 these tests will be sufficiently far along to guide tree planters who wish to use either parent as a pure species. They will also, in all probability, be flowering. At that time researchers in each of the states will make several artificial hybrids among the best origins of each species and establish a series of F<sub>1</sub> test plantations. Some of those F<sub>1</sub>'s will be greatly superior to today's hybrids, which in turn have already surpassed the wild parental types.

This story may sound a little too pat, for what about mass production problems? Fortunately, the Japanese and European parents bloom at nearly the same time. Hence, Syrach Larsen's suggestion of natural crossing gardens sounds feasible. His natural crossing gardens would consist of one self-incompatible clone of European (or Japanese) larch, surrounded by pollinating seedlings of the other species. The seedsman will have only to collect hybrid cones from the clonal parent. English research on fruit production shows another possibility. This work consisted of pegging lateral branches to the ground. They fruited heavily, and enable artificial pollinations to be made easily. Seed set data are such as to indicate that the use of hybrid seed would be economical if one man could pollinate more than a few hundred flowers per day.

**Scotch Pines for Timber and Christmas Trees**

Scotch pine is Europe's most common and widespread timber tree. Its natural range extends from Spain and Turkey on the south, to Scotland and northern Norway on the north, and to eastern Siberia on the east. Within these areas it is highly esteemed, filling all the industrial roles supplied in this country by a number of pine species.

American experience with Scotch pine was disheartening. It was planted extensively in the Northeast in the 1920's and 1930's. There was no attention to seed origin and most of the plantations are of such poor form as to be unmerchantable.
That need not be the case. Henry Baldwin's 17-year-old provenance study in southern New Hampshire shows that 90 percent of the trees grown from Latvian seed are as straight as the best American pines. That experiments puts the finger on southern Germany as the probable source of most of the poor-formed plantations of the past.

Scotch pine is now being planted in northern United States more than ever before. Michigan's nurseries alone produce 30 million trees per year. Most of the plantings are intended for Christmas trees. But production is so much higher than the Christmas tree cut that 90 percent of the Scotch pine seem destined to live to pulpwood or sawlog size.

This situation is the No. 1 challenge to the region's tree breeders. If the millions of trees now being planted are of improper origin, we shall have thousands of acres of worthless plantings. If the proper origins are used, those thousands of acres will produce as high quality timber as our best native stands. The 17-year New Hampshire study furnishes some of the answers to this seed source problem. But it is in New Hampshire and its results may not be applicable in the North Central states.

To satisfy the need for information applicable to Michigan's planting problem we started a new series of provenance tests in the summer of 1958. The first step was the writing of dozens of letters to European tree breeders, asking them to send small samples of seed from native stands in their vicinity. The response was good. We have received 320 different seedlots from about 200 different localities, well scattered over the natural range. Nearly all seedlots were accompanied by adequate descriptions of the locality of collection, of the qualities of the parent trees, and other useful types of information. The Russians were especially cooperative and sent 13 categories of information about each seedlot.

In the spring of 1959 we sowed 253 of the seedlots (all that had been received at the time) in the Bogue Research Nursery at East Lansing. We used a 4-replicated, randomized block design, in order to eliminate soil-caused differences from consideration. At the time the sowing job seemed like a large undertaking. So we "ran scared" — planned the details ahead of time. With this planning, the experiment was established in only 50 man-hours.

In the two years in which this experiment has been in the ground, we studied a total of 31 different characteristics. Not an occasional note, but a complete record of all 31 traits for all 1,012 plots, with complete statistical analyses of all data. This necessitated a radical departure from orthodox measuring and recording techniques. New ones had to be tried. Many were not only faster than the orthodox techniques but gave better quality data. The experiment has turned out to be almost routine — it has required only about 1/2 man-day per week during the growing season to do all necessary measurement and analytical work.

Next spring comes the hard part — the establishment of well-replicated test plantings in some 30 or 40 localities. Without these permanent tests, much of the nursery work would be wasted. Again we must "run scared". Most of the labelling work has already been done during the nice summer and fall days. Next spring it will be necessary only to lift the trees, tie them into several thousand bundles of four trees each, shuffle them by replication and outplanting, and deliver them to planting crews. If all goes well with the bundle-tying, the outplantings will proceed as fast as commercial plantings, even though they follow a precise statistical design.

These 2-year data give a good insight into the variation pattern within the species. It can be split into about 20 different geographic ecotypes. There is the Spanish ecotype, which is blue-green, short-needled, moderately fast growing, and produces a great many Lammas shoots. It differs very slightly from the southern France ecotype, which is a little slower growing and produces few Lammas shoots. The southern France and northern France ecotypes are separated in nature by only about 150 miles. But they are so different that visitors to the nursery wonder why they are called the same species. The trees from northern France are long-needled, green, very fastgrowing, and mature their buds appreciably earlier in the summer. These are a few examples of the different types which can be recognized.

In all 31 traits differences (statistically significant at the 1 percent level or less) were observed. The average 2-year heights ranged from 3 inches (northern Finland) to 14 inches (northern France). Fall color ranged from blue-green (Spain and France) to gold (Ural Mountains). Time of first-year bud set ranged from July 15 (northern Siberia) to early October (Spain and Turkey). There were even discernible differences in the ease with operations — trees from Spain, Turkey, and northern Finland pulled the hardest.

The various ecotypes show evident adaptations to the growing conditions at their places of origin. For example, the northern ecotypes are slow growing, set their buds early, have intense fall coloration, and are moderately short-needled. The German-Czechoslovakian ecotype has rapid growth and long needles adapted to the favorable growing conditions in Germany and Czechoslovakia.

This adaptation to climate at the place of origin is by no means complete. The German-Czechoslovakian population is more or less continuous. Constant pollen-flow and seed-flow have maintained it as a more or less uniform ecotype in spite of the fact that climates in various parts of the region differ. But between that population and the Vosges Mountains of northern France is a small range gap, across which there is no gene-flow. This permitted selection to work on the Vosges population as a unit.
causing it to be 15 to 20 percent faster growing than any of the German origins. What do these 2-year data mean? They are as useful for determining the pattern of variation within the species as data from other trees. Perhaps more useful, if we consider the fact that a day spent in nursery measurement gives as much data as does 10 days spent measuring large trees.

The 2-year height and color data correlate very well with a similar 17-year data from the earlier New Hampshire study where similar provenances were represented in both tests. In other characters we must leave it to the future to determine the importance of the early measurements. Our successors will measure the 25- and 50-year-old trees and correlate their measurements with our early results. They will be able to make use of the information in planning their work.

The permanent test plantings will start to give reliable information on the best seed sources for a particular locality in a short time — 5 or 6 years for Christmas tree growers and 10 or 15 years for foresters. That information will be only a part of the results of the experiment. Studies of single-tree progenies have shown that every one of the Scotch pine stands which was sampled was genetically variable. Hence, as soon as a planting has shown which geographic origins are best, it will graduate from a test to a breeding aboretum. Selective breeding to attain another 10 or 15 percent improvement will start.

Nine of the 2-year-old trees flowered at the start of their second year. Hence, it will be only a short time before the outplantings can be used in hybridization experiments. Eastern studies showed that Scotch pine crosses with Japanese red pine (*Pinus densiflora* Sieb. & Zucc.). The seed sets were low but the hybrids were extremely vigorous. It is reasonable to expect that a more fertile combination can be found by crossing several origins of one species with several origins of the other.

**Other Possibilities for the North Central States**

The white pines present several hybridization possibilities. Eastern white pine (*Pinus strobus* L.), western white pine (*P. monticola* D. Don), Himalayan white pine (*P. griffithii* McClel.), and the Mexican white pine (*P. ayacahuite* Ehrenb.) cross in all possible combinations. The seed sets are high and the hybrids are vigorous.

Jack pine and lodgepole pine (*P. contorta* Dougl.) also cross very easily. Some of the hybrids are growing in Michigan. They have about the same growth rate as the native jack pine but they are greatly superior in growth form. Both species fruit early and a large-scale improvement project would proceed rapidly.

I hate to single out any single exotic but a little work on the ginkgo (*Ginkgo biloba* L.) might return very large dividends. It is hardy in the warmer parts of the region, grows rapidly, and produces a very desirable white pine-type wood. Best of all, it is a monotypic species, and like most monotypes is free from insect and disease pests.

There is now a sizeable group of tree-improvement specialists in the region and a considerable amount of background information on tree genetics. Hence, we can expect the examples quoted here and a great many more to become available for actual forest planting within the next few years.

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**About the Author**

Jonathan W. Wright is Associate Professor of Forestry at Michigan State University. He joined the staff at East Lansing in 1957, after 11 years as geneticist with the Northeastern Forest Experiment Station.

Dr. Wright's research has been devoted largely to species hybridization and to geographic origin studies. His current work is devoted to extensive provenance tests of those species which are best adapted to Michigan's conditions. Approximately 50 percent of Dr. Wright's university time is spent in teaching. This includes direction of graduate students in forest genetics, one undergraduate course in forest genetics, and one graduate course in tree breeding.