HYBRIDIZATION IN IMPROVING SOUTHERN PINE

Keith W. Dorman

We have seen in the previous papers in this series the possibilities for aching improvement in tree species by selec ting better strains, better individuals, more disease-resistant types, and producing seed of these on a commercial scale. By so doing, we can produce in quantity the superior individuals now existing. If we make a further step and combine selection with still another operation--namely, the hybridization or crossing of superior trees--the chances are good that we can produce even better pines than now exist in nature. These will b e made-to-order pines, which we can't describe as yet because we've never seen them.

A good start in hybridizing has a1ready been made. Sensational results have been obtained in other regions and countries. Some hybrids grow two to three times as fast as the parents, and there is one of these hybrids suitable for planting in the West, the Lake States Region, and the Northeast. The important job now in tree selection combined with breeding is to produce a highly vigorous, disease-resistant, high-quality tree for planting in the South. The possibilites are exellent because we have nine species with a wide variety of traits in this general region. Crosses should be made between these species as well as with species from other regions and countries.

Methods and Purposes of Controlled Breeding

In forestry, controlled breeding has many possibilities for use in both intensiveand extensive methods. Intensive methods performed by hand are usuallyon a rather small scale and involve crosses between flowers on

Paper presented at Forest Genetics Conference, Atlanta, Ga., January 9 and 10, 1951.

the same tree, between trees of the same species, or between different species. Extensive methods are conducted on a much larger scale, as in seed orchards where isolated groups are planted in such a manner that cross pollination is under natural conditions. Control is obtained by composing the groups with selected material.

The intensive methods are suitable for experimental work and for producing matrial for establishing seed orchards. Both methods are at present included in forest tree-improvement progams in Australia, South Africa, Sweden, Denmark, Great Britin, Canada, and the Northern and Western United States.

We have seen that there are a number of ways of making controlled pollinations, and likewise there are a number of results to be gained. The methods to be used are governed by the objective desired, just as in other silvicultural or forest management practices. Some Of the advantages of controlled breeding are as follows:

1. It gives a very high control of quality in the offspring because both parents are known.

2. It proves a method, when combined with selection, for producing a much wider variety of genic combinations than is obtainable in natural populations, especially when species or races are crossed.

3. It may produce stock with hybrid vigor.

These items have immediate and practical value in the improvement of local tree species. We could start tomorrow and might have valuable leads within three or four years. There are two more advantages of controlled breeding that are of interest to long-range programs or basic studies of forest genetics. These are:

1. It gives, over a period of time, pure lines of very uniform material in self-pollinted plants.
2. It provides a method for studying inherent traits.

All of these points will be discussed in detail later on when we cover the southern pines in more detail.

History of Tree Breeding

It will help us understand some of the methods of controlled breeding and organize a program of work if we review briefly the history of fine and hardwood tree breeding. The oldest known attempt at deliberate crossing of forest trees is reportd by Klotzsch, who in 1845 amongst other species produced Pinus sylvestris x nigricans, Alnus glutinose x incana, and Ulmus campestris x effusa. Thus pine, alder, and elm figured in this first successful effort to breed forest trees. This work did not attract much attention, and neither did Luther Burbank's hybrids of walnuts produced in 1877 to 1887, although they too displayed very luxuriant growth. In 1909, N. Sylven began experiments with self-pollination and the progeny of wind pollination of Norway spruce as a basis for investigations into the inheritance of various branch types in that species. Ihe hybrid between Japanese and European larches, described by Henry and Flood, in 1919, attracted considerable attention among foresters. Crosses between two species of fir were made in Denmark in 1924. In 1932, A. Dengler published results of his work with Scots pine.

Since 1925, when the Institute of Forest Genetics was established in California, many crosses have been made with pine in the West. The Northeastern Forest Experiment Station has been working with hardwoods in the Northeast. A program involving more than a dozen agencies, some of which are in Canada, for breeding white pine for resistance to blister rust has been organized in recent years. The program of the Tennessee Valley Authority has attracted wide interest. The breeding program for poplars and disease-resistant chestnuts is quite well known.

The first cross with southern pines were in 1929 by Mr. Wakeley at the Southern Forest Experiment Station. The Institute of Genetics has a 17-year-old tree of a longleaf-slash pine cross and one of a shortleaf-slash pine cross. In more recent years crosses have been made between the four major species of southern pines, but none between selected trees of each species except on the new Callaway project in Georgia last spring. Very few crosses have been made with the minor species, such as sand, pond, Virginia, pitch, and spruce pines.

At Lake City, Florida, in 1943, slash pine trees selected for gum yielding ability were crossed. Progeny are now five years old. They were planted with seedlings from controlled pollinations between high-yielding and average trees and seedlings from wind-pollinated average-yielding and high-yielding tress. A very few crosses were made between slash and longleaf pine, but these were generally unsuccessful.

In 1942, Australian foresters inbred selected slash and loblolly pine. These were plus treesthat, on the basis of test result, have proven to be "elite" trees. Results of this work are, very significant, and will be discussed in more detail lateron.

In 1950, a project in tree improvement was started at Hamilton, Ga., near Columbus, under the Ida Cason Callaway Foundation in cooperation with the Southeastern Forest Experiment Station. The program includes testing of superior individuals, strains, and work in hybridization.

Results of Pine Breeding

What have we learned from controlled breeding with pine? We have learned how to do the job. This has meant solution of problems in pollen collection, extraction, and storage; also, solution of problems in bagging and pollinating the flowers. We have learned more about blooming habits. Improvements can be made, but we do have usable techniques right now. The publication "Methods Used to Control Pollination of Pines in the Sierra Nevada of California," U.S. Department of Agriculture Circular 792, outlines controlled breeding techniques.

Another thing we have learned as that some crosses give very vigorous offspring. This great vigor may be so high that in a very few years the hybrids are two to three times as large as either parent. Crosses between similar species, but from widely separated regions, have often given hybrid vigor. High vigor has been found in crosses between Jeffery and Coulter pine Ponderosa and Apache pine, lodgepole and jack pine, eastern pine and western white pine, and between western white pine and white pine from India. We have found high vigor in some cases in offspring between trees of the same species, but different geographic strains. In pine breeding work at the Institute of Forest Genetics, about one species cross an seve n has given increased vior in the offspring. Increased vigor has not been found in crosses made to data with southern pines. Most of the offspring are intermediate in regard to their parents.

We have found crossing very easy with some species of pine and very difficult with others. A summary of the work up to about five years ago showed that only those species with the same number of needles crossed readily.

There is some information on results of inbreeding. Pines are generally cross pollinated, as indicated by the difference in blooming period between the male and female flowers which we know occurs in some species. Inbred Scots pine, spruce in Europe, and Jeffery pine in California gave offspring with much lower vigor than wind-pollinated seed from the same mother tree. In Australia, inbred slash pine elite trees gave a larger proportion of top—grade offspring than wind-pollinated seed from the same tree or wind—pollinated seed from average trees in the stand. All the progeny were classified into five vigor form classes. Fifteen percent of the seedlings from the three inbred trees were in the best class. None of the seedlings from open—pollinated seed of average crop trees was in this class. The 15 percent may be a large enough group to form the final stand of trees. A total of 45 percent of the inbred stock was in the two top classes as compared with one percent of the open-pollinated stock. Putting these figures another way, from routine seed collection they got 160 top quality stems, from open—pollinated seed of superior trees 350, and from inbred seed of superior trees they got 570 good stems per acre. The inbred stock was definitely superior in form and vigor to the average material. In loblolly pine, the progeny were no better than those from wind—pollitiated seed from the same superior mother tree. They gave better trees than wind—pollinated seed from average crop trees, inasmuch as there were 13 percent as compared with 3 percent in the two best vigor form classes. Here is a concrete example of the value of selection and controlled breeding of southern pine. However, geneticists don't know what would have happened if they had crossed two elite trees instead of inbreeding each one. All this adds up to the fact that we don't know the full story about inbreeding. With southern pines we have data that is encouraging from one study with slash and loblolly pine. We don't know about the other species.

Before we leave the summary of what has been learned about breeding, we might consider some developments in an allied field. This has to do with chromosomal changes through mutations under natural conditions, or induced changes such as by special radiation or shock treatments. There is always a chance of sudden changes in genetic characteristics that may improve vigor or quality, and we should be on the lookout for them. So far, they have been of more interest in the hardwoods, such as the giant aspen in Sweden that has multiple sets of chromosomes. In the willows the basic chromosome number appears to be 38, but there is a parallel series of 44 chromosome forms, and sometimes representatives of both series appear in the same species. In one species, S. triandra, some individuals have 38 chromosomes while others have 44 or 88. In another species, S. Myrsinites, some individuals have 38 chromosomes while others have 190, or five sets of chromosomes. There is a mutation in shortleaf pine in the arboretum at the Institute of Genetics. It is a dwarf form and of little value. Sometimes these oddities are of value for special purposes. The Southeastern Station and other groups in the South are cooperating with Harvard University in testing seed that has been exposed to atomic radiation. The seed will not be planted until this spring, so there are no developments as yet. It may be advisable to pursue this type of work if it is warranted by current research with many crop plants.

Quite understandably, we have heard much of the striking mutations, especially those that have given rise to products of higher commercial value. Some geneticists feel that in the long run the small mutations that may not be so striking, but which occur in large numbers, are of much greater value in plant-improvement programs. These small mutations, as well as the large ones, may be an improvement or they may be in a downhill direction. In fact, these undesirable mutations are in general far more frequent than those which increase or intensify an organ or character.

Some Projects in Tree Breeding

A have discussed some of the methods of tree breeding, the objectives, and some of the things we have learned. Now let us consider some of the things that can be done. Most of the following suggestions are rather broad projects. These can be broken down into small units or studies, and many can be done separately for each species.

1. Make crosses between all southern pines. This is a quick once-over to sea if we can bet any measure of hybrid vigor with local species. Later on, crosses can be made between selected, disease-resistant trees of the best geographic strain to make use of the accumulated good qualities.

2. Determine effect of inbreeding for all species of southern pines. This is a rather important field of work because of its practical application to design of seed orchards. If inbreeding is not, harmful, it will be possible to plant orchards of few clones or only one clone to produce good seed. If it is harmful, we will have to plant several. This has been an important factor in Sweden, where they have a very few really elite trees. Also, we can produce a fairly large amount of for seed for establishing seed orchards by inbreeding just one best tree, assuming we'll have a variety of good trees to pick from.

3. Breed for special purposes. This is aimed breeding. We can breed for more height in southern pines. Perhaps this can be done, by crossing with certain western species. In the naval stores region, we wont a tree that produces a lot of oleoresin as well as one that is vigorous and has other desirable qualities. We will want to breed for disease resistance by crossing certain individuals, strains, or species. Increasing drought resistance by crossing with certain western and Mexican species may be vary important. Breeding for improved form such as narrow crowns, small branches, and better

natural pruning is desirable. Also, we may want to create or isolate types with uniform quality of wood as well as extremely light wood for newsprint pulp, or heavy wood for kraft pulp or special uses.

4. Methods of stimulating flowering in young trees. This is an important factor, and, if possible, may speed up both the long -range studios and production of quality seed in young seed orchards. A study of this type could begin with isolation of factors controlling flowering as well as application of methods for artificially stimulating it.

5. Improved tree breeding equipment and methods. For example, an improved pollinating bag that could be quickly and easily placed would speed up the field work. This is probably the most time-consuming part of the entire cross-pollinating operation. Present methods require stripping needles from stem, wrapping with cotton, removing seal from bag, placing bag over twig, and tying with string. Perhaps a bag with built-in cotton pad and elastic could be designed that would be much simpler to use. Some of the Swedish equipment for tree climbing should be tested.

6. Design of progeny tests. In this field there is need for some study that could probably be handled best in cooperation with statisticians. It is important, and may help speed up the work. We don't know whether we need ten or ten hundred trees in tests of various kinds for various objectives. In this same field we may want to use vegetatively propagated stock for accurate comparisons. This, of course, would require that rooting or grafting techniques be developed for producing stock of this kind.

7. Set up a catalogue of breeding stock. This would include individuals, strains, and plantations of introduced species.

8. Study of mutations and polyploidy. This field is of limited importance as long as we put the emphasis on pine breeding, but it may be very important in the work with hardwood species. We want to keep the

door open to material of this kind or techniques that may be developed.

Conclusions

This and preceding papers have qiven a bird's-eye view of the field of forest tree improvement. The job is now to organize the entire field so that we can make use of every means for a step ahead. The combined effect of good individuals, good strains, and vigorous hybrids may be very striking. There are going to be forests in the South for a very long time, and improvements in quality are just as much our responsibility as are other phases of forestry. Some measures to improve quality can be applied right now in our seed collection work. Others can be made in the near future as current studies are completed. Still more improvement will be possible as new work is finished. A broad program of genetic research should produce new and usable information each year, just as our programs in silviculture and forest management research do.