Improvement of Oaks

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This subject is by no means lucrative. A search of the literature and many personal letters failed to produce actual results of many oak improvement projects. This paper will have two primary aims; the first is to report current work being conducted on oaks and the second is to express some of my personal ideas on the selection and improvement of oaks.

Oak improvement started in Europe and Asia many years ago. It was believed that improvement could best be accomplished by crossing different species within the genus Quercus and selecting from among the hybrids. Therefore, until recently this has been the major breeding method employed for the improvement of oaks. However, within the last five years the trend has been toward the selection method so familiar to pine improvers.

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Ideally, one must determine whether racial or geographic differences exist within a species before individual selections can be made. One such study includes geographic sources of northern red oak (Quercus rubra L.) and is under the direction of the Ohio Agricultural Experiment Station and approved by the North Carolina-51 Committee. The study includes 31 origins and is planted in 12 localities in nine states. The cooperating agencies are the state experiment stations. Over-all nursery evaluation of this northern red oak study indicates, when all sources are included, that seed origin has a greater effect on seed weight and growth rate than female parent. However, exclusion of the most northerly origins reverses this conclusion. The implication is that individual tree selection will produce the greatest genetic gain and that racial differences within the areas from which selections will normally be made are relatively unimportant.

In addition, the effect of seed weight on seedling size was tested in the above study. Of the thirty-one origins only two were affected by seed weight. A similar study with chestnut oak (Q. montana Willd.) was established by the Tennessee Valley Authority. Three replicated lots of seed (20, 40, and 60 acorns per pound) failed to produce any difference in D^2H (diameter squared times height) in the seedlings produced. These two studies fail to confirm the common assumption that seed size affects seedling size.

A seed source study with southern red oak (Quercus falcata) under the direction of Clemson University and approved by the S-23 Committee will be started in the near future.

At North Carolina State University at Raleigh a Cooperative Industry Hardwood Research Program was started in 1963. Although initial efforts have dealt with site quality evaluation, and silvicultural and management explorations, genetic and variation studies will also be made. Currently an intensive research program is under way to study the variation in willow oak (Quercus phellos), water oak (Quercus nigra), and hybrids between the two. Preliminary results indicate no difference in specific gravity and fiber length when the two species are grown together. However, specific gravity does vary both within and between individual trees within a stand. This again points to individual tree selection as the best improvement method for these species.

Superior oaks are currently being selected by the states of Tennessee, Kentucky and North Carolina, and by the Tennessee Valley Authority. In the near future, the state of Georgia and the Hardwood Research Laboratory at Stoneville, Mississippi, will begin selection programs.

In addition to the above projects, there are several arboreta located throughout the area. The Michaux Quercetum at the Morris Arboretum in Philadelphia is one, and a replica of this is located at the Ohio Agricultural Experiment Station. Clemson University has an arboretum with over 250 exotic species including many oaks. TVA has a quercetum at Norris with 18 different species. An arboretum is to be established by Williams Furniture Company near Florence, South Carolina, and another is in the planning stages on the Land Between the Lakes in west Tennessee.

The Tennessee Valley Authority outplanted a small (four mother trees) open-pollinated chestnut progeny test this spring on University of the South land at Sewanee, Tennessee. Nursery evaluation of the material indicated a significant difference between families for diameter squared times height (D^2H). Future measurements will be made to see if this difference is maintained and also to obtain information on the optimum size for future progeny tests. In addition, exceptional northern red oak seedlings were selected from seedbeds this last spring and outplanted with other seedlings to see if the superiority is maintained. TVA is also investigating methods for stimulating early flowering in chestnut, northern red, and white oak, through the use of an early flowering rootstock, sawtooth oak (Quercus acutissima), and mature wood intergrafts. Results will not be available for several years.

Cross pollinations within species have been tried by the Central States Forest Experiment Station and the Southern Institute of Forest Genetics at Gulfport, Mississippi. One seed from 500 pollinations and 12 from. 140 indicate the difficulty encountered in pollination work with oaks.

This is about all the information available on current oak improvement work. My apologies to any projects not mentioned.

The second subject to be covered is the selection and improvement of oaks. As you perhaps know, TVA is currently working with chestnut, northern red, and white oak, and therefore this discussion will deal with these species. Although we have only about 50 superior tree

candidates of these species, many more have been looked at and rejected. To know what we look for and how we rank or grade various characteristics should be of interest to those of you who plan to start an oak improvement program in the near future. The best way to describe oak selection is to point out how it differs from pine selection, a subject you are all familiar with.

The greatest difference is the omission of "check" trees in oak selection. Basically, superior pine candidates are selected and compared with several surrounding "check" trees. The stand in which the tree is located is usually even aged and a pure or almost pure stand of that species. Most oak stands, on the other hand, are uneven aged with many different species. Here we have to deviate from the pine system with its check trees. We must be able to select and grade these superior oaks on the merits of each individual tree found on any site. We must be able to compare a good tree on a poor site'with a good tree on a good site.

A second difference is one present today but one that could change considerably in the future. This is the different use of oaks as compared with pines. Current work with pines includes wood property studies because of the large use of these species for paper production. However, oaks are usually grown to sawlog size and used for veneer, flooring, furniture, etc. Wood properties are certainly important but not nearly as much so as in pines. Increased use of hardwoods for paper manufacture over the past few years is expected to continue and certainly wood properties should be included in oak and other hardwood improvement programs.

Now, let us take a hypothetical walk through a hardwood stand and look for superior oak candidates. We will eliminate all trees that are crooked, have epicormic branching, and are poorly pruned. We next approach apparently straight trees and look up the bole to be sure it is straight. If the tree is perfectly straight for at least two logs (32 feet), we look at the bark, noting ridges and pattern. If spiral grain is evident, the tree is eliminated. If the tree is perfectly straight for at least two logs, well pruned, and straight grained, we step back and look for defects in the first log (16 feet). These are usually branch-caused defects and will depend on the diameter of the tree. If the tree is still good at this point we grade it.

Let's look at each characteristic individually--

1) Straightness: Note that we consider only the first two logs, but let me add that this is the minimum standard. This length is based on a prediction of the size we will allow future oak plantations to attain. Once the butt log is large enough to grade as prime or veneer we have reached a plateau. Further value increase depends on growth rate. Therefore, since the highest value paid for oak timber is for veneer logs we should allow the plantation trees to at least attain this plateau. This means plantation crop trees should be at least 18-20 inches dbh before they are cut. In such a tree the second log will not grade better than number two and the third will probably not grade better than number three. Log studies have indicated that the monies received for lumber cut from a number three log will not cover the expenses of manufacturing such a log. In addition, if the remainder of a two-log tree is in crown, such a tree will attain a given diameter, say 20 inches dbh, in a shorter period of time than a three-log tree. These are the reasons that the first two logs are the most important part when oaks are being selected.

2) Spiral grain: This trait is present in almost all oak species. It has been shown to be a detrimental characteristic in cutting and finishing oak lumber and veneer. No one has proved that either the environment or genetics of a tree is the cause, but evidence and logic point toward genetic control of this trait. Spiral grain should automatically eliminate a potential superior tree no matter how good it is otherwise.

3) Defects: Presence of branch-caused defects indicates two things: first, that lumber quality will be poor and, second, that the tree did not prune itself well. This pruning ability must be qualified. Any tree 14 inches dbh and larger should be defect free for at least the first log. The smaller a tree is the more defects one allows. However, epicormic branches should not be tolerated. A 10-inch dbh tree without defects in the butt log indicates a good pruner. It can also be assumed that this tree will be free of defects at 20 inches dbh. However, you cannot assume that a 20-inch dbh defect-free tree was free of defects at 10 inches. Therefore, selection of small superior trees (down to about 7-8 inches dbh) seems surer than selection of larger trees. By selecting for lack of defect we are indirectly selecting for branch characteristics. Consequently, branch size and angle are not strong factors in our selection system.

4) Growth rate: In oaks, as in most hardwoods, extreme growth rates are not desirable.

Uniform rates are more important. Trees growing at the uniform rate of 2 inches in diameter every 5 to 10 years are desirable. Faster rates are acceptable, but slower rates should not be considered.

5) Form class: There is little we can say about this except that the higher the form the better.

6) Crown characteristics: In general, the crown should be well shaped, full, and healthy. The aim should be maximum growth on individual trees rather than trying to squeeze a few more small crowned trees on each acre.

7) Total height: This should be considered and measured, but because apical dominance is not prevalent in oaks it should not be a critical factor in selecting superior trees.

Ideally, selection criteria should be based on the results of genetic studies. Such results are not available in oaks. Therefore, we select trees on the basis of important economic characteristics but weigh these traits with genetic logic based on results of work with other species. If I had to rank the previously described characteristics in order of importance in oaks, my list would look about like this:

1) No spiral grain.
2) Perfectly straight for at least two logs.
3) Trees free of defects or with a minimum of defects in the butt log and no epicormic branching.
4) Uniform, relatively fast growth rate.
5) High form class.
6) Desirable wood properties.
7) Total height.
8) Desirable crown characteristics.

A close look at this list will show that we are not selecting for eight characteristics as the list implies. The first two are yes and no traits. We have simply restricted the population to trees that are straight for two logs and do not have spiral grain. The next step is to select fast-growing, defect-free trees from this restricted population. The last four--form class, wood properties, total height, and crown characteristics--are not heavily weighted. If a prospective tree can get by one and two and rates high in three and four, a poor showing in any one or all of the last four will not necessarily eliminate it. So really, the system is based on two major selection criteria, growth and defect, and four minor criteria.

Suppose we have made all our selections. The next step will be seed orchard establishment. Grafting has been covered in a previous paper and will not be discussed. But certainly the question must be asked, How large an orchard do you need. Let's assume that in 20 years the orchard will produce about 1,000 sound seed per tree. With this figure one acre of white oak seed orchard spaced at 30 feet by 30 feet would produce about 50,000 seeds. This acreage should be increased several times to overcome individual tree fluctuations of good seed years and thus insure seed each year. Therefore, an organization expecting to plant 500,000 oak per year might consider a 20-acre seed orchard adequate. This basic requirement should be available each year, but considerably more than is needed will be present in certain good seed years. Until successful storage methods are found, we can depend only on the current year's crop.

Another problem that must be faced is progeny testing. As previously mentioned, cross pollinations have been very unproductive. Where one makes 40 pollinations to insure getting 500 seeds in pines, one would have to make many, many times this number in oaks to obtain the same amount. We must conclude that until better success is possible, controlled pollinations for progeny testing will be impractical. This means that open-pollinated tests must be conducted to test oak seed orchards.

In conclusion, there are two points that I would like to make. It would be very helpful if oak pulpwood, sawlog, and veneer users would let us know what type of tree they want, particularly with reference to specific gravity, fiber length, and other wood properties. Second, the discussion on the selection of oaks includes my own ideas on the subject and is presented primarily to stimulate the thinking of current or future hardwood tree improvers. All inquiries and opportunities for discussion on oak selection are encouraged and welcome.