# WHERE WE STAND ON TECHNIQUES AND SEED ORCHARD CULTURE

## Selection of Superior Trees

A. E. SQUILLACE [1/]

Most forest tree improvement programs in the south entail some form of mass selection. That is, rather than using random trees as a starting point, tree breeders usually select individual trees that are phenotypically superior in respect to the traits they are interested in improving. Many programs depend heavily upon the benefits of this practice. This subject, therefore, is important to most of us.

I shall not attempt to outline or discuss the various selection techniques employed in the many tree improvement programs of the south. Rather, I shall discuss some of the concepts involved in the effectiveness of mass selection and then make a few suggestions for increasing the efficiency of this practice. The discussion will be limited to selection as it applies to selective breeding programs, with emphasis on southern pines.

### The Basis for Mass Selection

In mass selection we attempt to estimate the breeding value of trees--the ability of each tree to produce superior progeny. Judgment in this kind of selection is based entirely on the appearance or performance of the tree itself. The technique differs from "progeny test selection," where the tree is evaluated on the basis of the appearance or performance of its progenies.

Mass selection is effective only to the extent that there is some degree of resemblance between parents and their offspring. In other words, to make genetic gains by this technique there must be a positive offspring-parent regression. The extent of the offspring-parent regression depends greatly upon the magnitude of the environmental effects in the parental population. If such environmental effects are strong, the offspring-parent regression will tend to be weak and genetic gains will tend to be small. If the environmental effects are weak, the parent-offspring regression will tend to be strong and gains will be large.

Because of the dependence upon environmental effects, offspring-parent relationships can vary greatly from one population to the next, even if the genetic variances are equal. For example, take a handful of seed and split it into two parts. With one part, establish a plantation in the normal manner on a prepared site. With the other, establish a simulated natural stand by planting the seeds over a period of several years on a rough site and at a highly variable spacing. When the trees mature, make selections in these two stands and grow their progenies in plantations. Which' population should show the greatest offspring-parent relationship? Obviously, it would be the normal plantation. The trees in the simulated wild stand will be highly variable because of the induced environmental effects. The parent trees selected here would appear to be superior but often would not prove to be genetically superior upon progeny testing. Selection in the normal plantation would be much more efficient in capturing genetic gains because of the minimized environmental effects.

Other factors that can affect the offspring-parent relationship are the magnitude of the genetic variance occurring in the population and the mode of inheritance. However, there is not much we can do about these with respect to increasing the effectiveness of selection.

But we can do something about environmental effects. We can, for example, select from plantations whenever possible. Lacking suitable plantations, we can select in areas where site, age, and other environmental factors are relatively uniform. Finally, we can attempt to adjust for environmental effects.

### Determining the Effectiveness of Mass Selection

The most reliable way to determine the effectiveness of mass selection is to grow the progenies and determine empirically how much gain is made. However, it is usually necessary to grow the progenies for a number of years before they can be properly evaluated. It is desirable to obtain an estimate of the genetic gains to be expected at the time selections are made. In making such estimates we must be careful to use the proper estimates of heritability. Most authors who publish heritability data cautiously point out that their estimates apply

1/ Principal Plant Geneticist, Naval Stores and Timber Production Laboratory, Southeastern Forest Experiment Station, Forest Service, U. S. Department of Agriculture, Olustee, Florida.

only to the populations they worked with or to similar populations. This is especially important when estimating gains from mass selection.

Most estimates of heritability reported in the literature were determined from progeny data alone. That is, the estimates were based on the resemblances among trees within families. These families were usually growing under plantation conditions on nicely prepared sites, and the heritability estimates apply to selection under such conditions. They would not apply to selection in a wild population.

If mass selection is practiced in a plantation, heritability estimates obtained from progeny data alone may be applicable. But if selection is practiced in wild stands, the heritability estimates should be based upon offspring-parent regressions. Unfortunately, these are relatively rare in the literature. Usually such estimates, for a given trait, are considerably weaker than estimates made from progeny data alone. A good example is available in data reported by Farmer and Wilcox (1966) for eastern cottonwood (Populus deltoides Bartr.). Using offspring data alone, they estimated narrow sense heritabilities of .62 and .40 for wood specific gravity and fibre length, respectively. In contrast, heritabilities based upon offspring-parent regressions were only .18 and .32, respectively. The parents were growing under natural conditions.

As another comparison, Squillace and Bengtson (1961) reported estimates of .31 and .18 to .35 for volume growth in slash pine, based upon progeny data alone. In contrast, Peters and Goddard (1961) reported an estimate of .15, for the same trait and species, based upon offspring-parent regression where the parents were growing in the wild.

The difference in the two kinds of heritability estimates in the above examples may be partly due to the fact that the offspring were considerably younger than the parents in both cases and that, in a sense, two different traits were involved. However, the difference in environmental effects between wild stands and plantations very likely was **also a** strong factor.

### Mass Selection vs Progeny Testing

The relationships between mass selection and progeny testing must be considered. These two facets of tree improvement have the same objectives and are often utilized together.

In progeny testing we are not concerned with the extent of the offspring-parent relationship because the environmental variation affecting the parents is not a factor. Through progeny testing, genetic gains can be made even if the environmental effects in the parental population completely mask the genetic differences.

Because both mass selection and selection on the basis of progeny testing can be effective, the important question becomes: How much relative effort should be spent on these two techniques? To get a precise answer to this question for a specific situation we would need to consider all pertinent statistics available, such as the probable extent of the offspring-parent relationships and the relative costs in time and effort. As a general rule, if the offspring-parent relationship is strong, relatively more emphasis should be placed on moss selection. If it is weak, relatively more emphasis should be placed on progeny testing. More will be said on this point later.

### Improving the Efficiency of Selection

Following are some recommendations for improving the efficiency of mass selection and increasing genetic gains generally.

1. Pick the best stands for making individual tree selections. The reason for this is that stands of trees may vary genetically, even within relatively small regions, because of genetic isolation, clinal variation, or other factors. The stand itself may be a reflection of ancestry and, hence, also of its progeny. The stands should be within the general region within which we plan to utilize the superior material, unless non-indigenous seed has previously proved superior to local sources. By picking the best stands we might make a genetic gain above that made through selection of individuals within ordinary stands.

2. Prefer stands that are relatively uniform in respect to age, spacing, and microsite. The ideal stand would be a plantation established from seed collected from numerous trees growing over the region being dealt with. If selections are made hi such stands the offspring-parent relationships are apt to be high. Of course, ideal stands are rare, but I strongly suggest that we establish such plantations for species not yet being improved. Lacking ideal stands, we should pick the most desirable ones available.

3. Make ail possible adjustments for environmental effects. The University of Florida technique for improving the efficiency of selection for growth rate by adjusting for crown size is an example of a rather refined procedure. However, less refined techniques are also possible. Proper choice of check trees, against which the selection is compared, is important.

4. Concentrate on relatively few traits. I don't believe we can produce a perfect tree in all respects from one generation of selection. As the number of traits increases, we reduce the maximum possible selection differential on all traits used. The traits chosen should be those that are apt to give the greatest gain, because of high economic value, high heritability, or other factors. The less important traits should receive attention only to the extent of avoiding negative selection. Such traits can receive more attention when beginning the next

cycle of selection, where the trees will be growing in plantations and where we have already made a gain in the more important traits.

5. Develop and use selection indices. Selection indices insure the greatest possible gain when selecting for a combination of traits. This is true, not only because of the statistical manipulations, but also because they eliminate much of the personal bias often encountered in selection. The necessary ingredients for constructing refined indices are heritabilities, phenotypic correlations, genetic correlations and relative economic weights. This information is becoming available.

6. Weigh the relative merits of progeny testing and mass selection. Application of both techniques will usually give the most genetic gain. The problem is to determine how much relative effort should be allocated to each technique.

If selections can be made in plantations approaching the ideal mentioned earlier, we can get by with relatively few selections and a minimum amount of progeny testing. In some cases, appreciable genetic gains may even be made without progeny testing, through repeated mass selection.

In contrast, if it is necessary to select in natural stands containing variation in age, spacing, microsite, etc., we should spend relatively more effort on progeny testing. The number of selections should be great enough to permit a heavy roguing of clones that do not prove to be superior on the basis of progeny performance.

Most of our current programs, based as they are on selection in wild stands, fall in the latter category. In many cases, enough selections were made to permit roguing of at least half of the clones after progeny testing, and appreciable gains should be made. However, we should now make preparations to maximize opportunities for further improvement in the next cycle of selection. Plantations should be established, as soon as possible, from progenies of large numbers of selections, preferably those proven to be superior. Organizations working with the same species and in the same region should be encouraged to pool their material. In such plantations additional genetic gains should come easier, even through mass selection alone.

## Summary

Control of environmental effects in the stand in which selection is made is the key to effective mass selection. Selection should be made in plantations if the seed source is known to be suitable and if it was established from a mix of seed from many trees. Under such conditions the number of selections can be held to a minimum to reduce the cost of progeny testing. For species in which the initiation of tree improvement work will be delayed, we should establish suitable plantations as rapidly as possible to provide material for effective mass selection.

Lacking suitable plantations, the breeder should 1) select from ,the best wild stands available, from the standpoint of both superiority and uniformity of environmental factors; 2) adjust for environmental factors to the extent possible; 3) select and progeny test relatively large number of trees to permit heavy roguing after progeny testing; and 4) establish plantations from progenies of large numbers of selections, to be used as a base for the next cycle of selection.

## Literature Cited

Farmer, R. E., Jr., and J. R. Wilcox
1966. Variation in juvenile growth and wood properties in half-sib cottonwood families. U.S. Forest Service Res. Paper NC-6:1-4.

Peters, W. J., and R. E. Goddard
1961. Inheritance of vigor in slash pine. Sixth South. Conf. on Forest Tree Impr. Proc., pp. 80-84.

Squillace, A. E., and G. W. Bengtson.
1961. Inheritance of gum yield and other characteristics of slash pine. Sixth South. Conf. on Forest Tree Impr. Proc., pp. 85-96.