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OPPORTUNITIES FOR SELECTING SUPERIOR PHENOTYPES

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Phenotypes exemplify the variations which occur within wild plants. According to Forest Terminology,8/ a phenotype is defined as "the organism as exemplified by its expressed characteristics as contrasted to its genetic construction (genotype). It is the plant as we see it." This natural selection of forest trees, which is constantly going on, may ultimately lead to pure crops of a definite local race, or physiological variety. When this of phenotypes having superior characteristics for the particular site in question and thus may lead to the development of a genotype which may reproduce itself. In the field of horticulture, selections which are vegetatively propagated form the backlog of the business.

If a genetics project with the southern pines is to be undertaken seriously, one of the first objectives should be the recognition of and location of superior phenotypes. Once found, the trees having the characteristics desired may be multiplied vegetatively and used for breeding purposes in order to develop genotypes combining various desirable characteristics which may be passed on to their progeny in a high percentage of cases. Thus it is important that we realize that before much can be done in the way of developin true hybrid strains, it will be necessary to collect these phenotypes,

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multiply them, and put them in orchards which can be used as a source of breeding material for artificial crossing, a place where natural crosses may be developed, a place where these superior strains may be tested as to their adaptability to the locality and for use as seed orchards.

Although the characters marking phenotypes may be visible to the naked eye, many phenotypes may be characterized by features which are microscopic or hidden. Some of the more easily recognized characteristics would be crown form, bole form, character of branching, size or coarseness of branches and other branching habits, seed production, and disease resistance. Other characters which may be superior in some phenotypes that are not so obvious would be variations in wood quality, such as fiber length, specific gravity, wood composition, figured or unusual grain, heartwood, durability, and many others. For example, variations in the gum yield of southern pines have already been studied and selections have been made which will produce higher yields, but very little development or research work has been done on other variations which occur in the southern pines.

As a beginning, those interested should recognize that phenotypes with either especially desirable or undesirable characteristics may have developed through generations of adaptation to the environment, and that no two individual trees are alike among the southern pines. Among the infinite variations which occur, some are much better than others with regard to specific characteristics, and these should be sought out and used in a breeding program if the optimum productivity of the southern pine forest region is eventually to be achieved.

sometimes deviations from the normal type are readily observed, but more often they are discovered only through positive observations taken in a scientific manner. This is particularly true in the case of the pines where differences due to spacing, soil, fire, and other environmental factors may have caused variations difficult to separate from those caused by natural selection through several generations. The true value of such trees when selected for use as parents can only be determined by the performance of the offspring, and considerable investigative work is necessary in order to ascertain that the characteristic supposedly discovered in a certain phenotype may be of real value for breeding purposes. Some of the more obvious examples of phenotypes may be found more readily in red cedar than in pine, and these are mentioned because they are so commonly observed and have become recognized varieties in horticulture. The columnar cedar, the global cedar, the pyra midal and procumbent types are commonly seen. All of these include variations, from fine, erect branches to coarse branches and drooping branches, which may have significance in developing superior trees. The effect of such habits of growth may have a direct relationship to wood production, both in quantity and quality. It would seem obvious that finely branched specimens would have smaller knots and a higher quality of lumber than those coarsely branched. For example, an erect, finely branched Virginia pine would produce lumber with smaller knots and of higher grade than one with coarse branches which prune with difficulty, either naturally or artificially. An increase in #1 common and better produced from Virginia pine would be a real contribution to poor site productivity.

In considering the theoretical ability of trees to produce wood, for example, suppose we might study the effect of crown for wood production. The efficiency of trees in achieving a high rate of growth, other conditions being equal, may be due primarily to the amount of solar radiation received by the chlorophyll. These rays are used by the chlorophyll in the manufacture of food and wood and thus one might deduce that the crown forms which intercept the greatest amount or perhaps some other given amount of sunlight will be most efficient in wood production. Thus the propagation of such phenotypes in our future forests might prove exceedingly valuable in improving growth rates.

The possibilities of improving wood quality, such as mentioned in connection with the finely branched Virginia pine, may have even greater possibilities. Or, if figured wood from walnut, maple, or birch could be reproduced, this would be of groat importance. These examples are not beyond the realm of possibility and afford an opportunity to the industry to greatly increase its returns in the long run.

In the past, however, much of the effort in the woods has been in the opposite direction. Practically all of the grade yield studies that have been made show that the trees now being sawed are largely of low grade and relatively large (18" +) size in the hardwoods. Small trees are cut if they are of better grade; the low grade small trees are left. The trees commonly left are of poor form, low disease resistance and low quality. The superior individuals have been removed. The progeny from such trees cannot be expected to regenerate the forest with superior individuals which will produce the high grade lumber the market has been accustomed to in the past. On the brighter side, more and more trees are being marked for cutting by foresters and there is at least some conscious selection of the poor trees for harvesting and of the better trees to be left for future growth and for regeneration of the stand. This type of selection has significant genetic aspects and, in the long run, will provide considerable improvement in the quality and growth characteristics of our forests. Thus the possibilities for tree and stand improvement range from the selection of phenotypes representing the better individuals in connection with marking operations to their conscious selection and multiplication for breeding purposes. Some of the more significant examples of variations which should be sought will now be discussed.

The following discussion is arranged in order of the particular tree characteristic representative of the phenotype concerned and will largely cover some of those noted by Dorman in his paper, "Genetics of Southern Pine."3/ Another presentation which might have been used would be to discuss the causative agents which resulted in the determination of phenotypes, such as frost conditions, soils, maximum and minimum temperatures, closeness of canopy, wind, burning, pasturing, snow, etc. This is the presentation followed in Busgen and Munch, "Structure and Life of Forest Trees."2/

Crown Form

This has already been discussed as an example in connection with the red cedar. However, phenotypes which develop a true columnar form, probably resulting from trees being subjected to continuous competition in a densely growing forest, should be sought. As pointed out previously, trees of such form usually have smaller limbs and make use of more solar radiation than other forms of crown. They are generally also more resistant to snow and ice damage but when opened up may be more prone to windthrow. These considerations are all important to the southern pines in some sections of the South. If, over a long period, conditions become so unfavorable that a close canopy cannot be maintained, upright growth of trees is discouraged and they are then generally disposed toward a broader and lower growth, which makes less effective use of the site. In Germany pine from the southwest part of the country is regularly damaged or crushed by snow if transplanted into the mountains. On the other hand, the upland pine with its relatively slender crown and pliant branches, withstands regularly the heaviest loading of snow. 2/ This difference in form is also striking in the case of the Rocky Mountain and Pacific Coast varieties of Douglas fir. Very little seems to be known concerning the respective efficiency of various crown forms found in southern pine but the subject would seem to be a promising field for investigation.

Stem Form

One of the best known examples of the use of phenotypes with good stem form is the use of the shipmast locust as compared to the common locust, with which you are familiar. In the Tennessee Valley area we have tested numerous clones of the shipmast locust and have found the Kimberley locust from Long Island and the Higbee locust from southern Indiana to be the best combination of straight stem and rate of growth for Tennessee Valley conditions, but growth is slower than common locust. Selections from these clones for durability have not yet been made.

To a considerable extent, the same differences in stem form are quite obvious in Virginia pine in various parts of its range and I have observed some similar differences in loblolly pine, especially in Kentucky. Usually the most vigorous tree in the seedling and sapling stage is the one inclined to develop poor stem form. This was found true with slash pine collected from six sources and planted in four locations in South Africa. The trees which showed the poorest form throughout were the most vigorous growing of the imported stocks which, by the way, came from north Florida. Again, in the case of loblolly pine, the Florida and Louisiana stock was significantly superior to most of the others in rate of growth and was also inferior in form.7/ Pinus rigida, pitch pine, also varies considerably in stem form from locality to locality and the straight stemmed selections might be worthy of propagation. That Stem form is inherited has been well proven and tested in Switzerland, Germany and Sweden.4/

Growth Rate

Selections for optimum growth rate and volume per acre have good possibilities in the southern pines. Some of the most significant studies have been made in South Africa where trees grown from slash pine seed collected in British Honduras and from Georgia is were grown on comparable sites. The plot of British Honduras origin grew twice as fast as that of the United States origin. The rate of growth for all of the loblolly and slash pines tested there varied greatly with the latitude, increasing quite regularly as the plantations were located further south. This gives some indication that there may be different clines represented in this species at various latitudes.7/ Last year some tests of seedlings of loblolly pine from several locations in the South were started by several agencies cooperating in the project, using trees furnished by TVA from known seed sources. This is just a beginning in this field, but is indicative of the kind of cooperation which may be necessary in order to successfully pursue projects of this character.

Wood Quality

Variations in fiber length are known to exist within trees and ore known to vary somewhat from tree to tree in a given species. This is also true of specific gravity. The evidence, however, is so far inconclusive and warrants further study, particularly because of its importance to the pulp and paper industry and its relationship to paper quality.

Disease and Drouth Resistance

Wakeley,10/ in connection with seed source studies, found considerable variation in the susceptibility of loblolly pine to infection by cronartium. Trees of local stock from Louisiana had only a 6.5 per cent infection, whereas Georgia stock had 32.1 per cent trunk infections. In the case of brown spot disease in longleaf pine, disease free seedlings may be observed growing beside those with a high degree of infection. It was found that the resistant seedlings exuded a higher percentage of resin than those which were susceptible to infection. Some experiments with white pine being tested for resistance to blister rust are showing significant and encouraging results. These tree selections were made because they showed no blister rust after fifteen to twenty years natural exposure to infected Ribes.6/ In the Tennessee Valley we have had some experience in making selections of hybrid poplar clones for resistance to the canter disease. Out of 35 clones tested, only one, No. OP 32, was found to be sufficiently resistant to cankering.1/ Thus it would seem that selections of southern pines for resistance to some of the more common diseases, such as blister rust, needle cast, brown spot disease, canker and little leaf disease, might prove of benefit in the development of resistant strains.

Heat Requirements and Frost Sensitivity

The Woody Plant Seed Manual9/ recommends that seeds used in commercial seedling production be collected not more than 150 miles from the point where they are to be planted. This is largely in recognition of the fact that local races have developed which transmit to their progeny a very marked sensitivity to temperature and perhaps soil conditions. I found long ago that yellow poplar grown from seed collected in South Carolina froze to the ground in the nursery in Ohio. Such observations on first year growth are readily made in tree nurseries. Dorman3/ points out that one year old slash pine from Cuban and British Honduras seed, which was sown in Texas in 1929, was much less frost resistant than stock from Florida seed. Lots of shortleaf pine from several origins grown in a Louisiana nursery showed great differences. Trees grown from Pennsylvania seed ceased growth much earlier and grew less than those grown from seed collected in Texas. (Of course this would be expected from Texas seed.) Loblolly pine trees, probably from Georgia seed, were grown in southern Ohio for many years, until the cold winter of 1930, when temperatures reached -26^{0} F., killed the stands completely, after the trees had attained diameters of 9-10 inches. Thus, extreme care will need to be exercised in selecting phenotypes for propagation for a particular characteristic to give adequate consideration to corollary characters or the whole purpose may be upset by some character which mikes the tree unadaptable to the situation for which its use is proposed.

Seedling and Flowering Habits

These vary greatly with changes in latitude and vary characteristically even within relatively small areas and by individuals. Thus, for example, tests of the progeny of good seed producers are necessary to determine whether or not this is an inherent trait or simply a phenotypic condition. For instance, Pomeroy5/ found in 1949 that over a nine year period the most prolific trees matured cones each year, whereas seed crops generally occurred only at intervals up to five years. Some individual pine trees characteristically have few cones, while others fruit heavily. This is of particular importance if clones are to be propagated from superior phenotypes for the purpose of developing seed orchards. Unless we select phenotypes which will produce abundant crops of seed the testing of these may be considerably delayed and their usefulness as seed sources materially reduced. This may be tied in directly with the flowering habits of the trees and these should be studied for each of the species of southern pines as a part of the proposed program.

Research Program Possibilities

A program of selection would inevitably extend. over a very long period of time and therefore must be well organized and assured of permanent staffing and financing. This is a subject which should merit a great deal of thought and careful consideration by this group. Technically, the field breaks down about as follows:

1. Propagation of selections
    A. By grafting
        a. Techniques
        b. Influence of stock on scion (compatibility)
    B. By cuttings
2. Development of arboretums geographically and climatically distributed for growing, testing and holding selected phenotypes. These arboretums will provide locations at which the character and form

of trees obtained by vegetative propagation may be studied.

3. Study and select desirable phenotypes throughout the range of each species of southern pine. Those having desirable characteristics would be tested as provided above. In this connection, a uniform system for identifying southern pine phenotypes and clones should be developed. Some material has already been published in this field and other studies are now under way. For example, TVA is contemplating making selections from the millions of trees now produced in its nurseries from various seed sources. It is planned to set out in orchards those one-year seedlings which are 50% or more taller than their immediate neighbors. These individuals will then be available later for testing, seed collection, and hybridization studies.

4. Locate stands representative of the superior pine phenotypes for each species, these stands to be used for seed orchards, from which seed can be obtained which will produce a higher percentage of superior individuals than that now normally obtained in commercial practice.

5. Study the phenology of the southern pines, including flowering habits, seeding habits, seasonal growth, and other characters which would affect the usefulness of individuals in hybridization and other breeding studies.

6. There should also be considered the establishment of a central agency to coordinate studies and projects and develop standardized techniques. This agency could act as a central source for information and would seek support for breeding investigations from private agencies. It

would be the central core around which the genetic development of southern pines could take place and should provide for the cooperation of all agencies, both public and private. Without some organization of this type, duplication of effort is bound to occur and the cost of individual projects would be greater than if coordination could be achieved. Furthermore, the necessary geographic and climatic distribution of testing grounds makes it almost essential that the development of such a coordinating body be considered.

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