Possibilities of Tree Improvement as Indicated

By Development in Other Fields

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Let me express my appreciation for the opportunity of appearing on your program here today to discuss some of the possibilities of tree improvement as indicated by developments in other fields. Development of the science of plant breeding really antedates Mendel and the workers of this period. It is an applied science that is carried out efficiently only through the application of othor basic plant sciences. The rapid increase in the knowledge of genetics since the rediscovery of Mendel's laws of heredity in 1900, and the application of these laws to plant breeding, were essential steps in the development of plant breeding as a science. The contributions of cytogenetics in recent years have furnished in many cases a clear picture of genetic relationships based upon differences and similarities of chromosome morphology, structure, and function. Many economic plants are polyploids and a knowledge of chromosome numbers, pairing behavior, in crosses ,and gene differences among related species and varieties is essential in building new varieties of plants with the characters designed by the grower and consumer. Physical and chemical methods of inducing changes of chromosome numbers and structure and of inducing gone changes are being developed. Satisfactory techniques for inducing polyploidy in species and hybrids are available for certain types of plant breeding.

In order to evaluate a variety which has been developed it is necessary to compare it with varities of known performance. The comparisons made by the plant breeder are extensive and frequently only a few replications can be grown. The devolopment of adequate statistical methods has aided greatly in making reliable comparative trials. Experimental methods of making reliable comparisons are one of the tools of the plant breeder.

Methods have been devised in many cases for differentiating quality for a determination of the relative value of different characters, including chemical properties, make it possible under conditions of control pollination to select for the characters desired. In problems of breeding for disease resistance a knowledge of genetics of the pathogen is as essential as that of the crop plant itself. With each individual plant, information regarding available varieties, their characters, and their wild relatives furnishes a basis for the combination of genes desired by the breeder. For diseases caused by pathogones it is equally important to know the probable mode of origin of new strains of the organisms, and the number, distribution and genetic nature of the strains present in the region where the crop plant is to be grown.

A wealth of information is available regarding the genetics of crop plants and the progress which has been made by the application of genetics to their

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breeding and improvement. It seems, therefore, unwise to attempt hero to make a complete review of the present status of the progress which has been made in connection with the breeding of certain species. The literature is voluminous in regard to this and I shall, therefore, attempt now to cite what I think to be some examples of progress that have been made by plant breeders and try to point out what the opportunities appear to be for the development of superior varieties, hybrids, and strains of forest trees by scientific breeding methods. However, before the citation of these examples, I should like to make a few observations concerning what I think to be of fundamental importance at this point. Plant breeding today is more than an art. In order for a plant breeder to be productive and efficient in his work it is necessary that he have fundamental training in the biological sciences. Some of the more important phases of this training may be summarized as follows:

1. A knowledge of genetic and oytogenetic principles.

2. A knowledge of the characteristics of the crop to be improved including its wild relatives.

3. Information regarding the needs of the grower or the producer.

4. A knowledge of special techniques adapted to the solution of the particular problem or problems at hand.

5. A knowledge of the principles of field plot technique.

6. A knowledge of the principles involved in the design of experiments and the statistical reduction and interpretation of data,

I should like now to discuss briefly some of the developments which have been made by plant breeders in an effort to indicate to you what may reasonably be expected in the field of forest tree improvement where the tools of the geneticists, cytogeneticists, etc. as well as the statisticians are brought to bear upon the problem of forest tree breeding. Several years ago a cooperative project between the University of Minnesota and the Office of Cereal Investigation of the United States Department of Agriculture was initiated for the purpose of developing a variety of spring wheat which *was* resistant to stem rust. Personnel who cooperated on this project consisted of agronomists, plant geneticists, chemists, plant pathologists, etc. In the studies, a rtificial epidemics of stem rust were developed both under field conditions and in the greenhouse. During the early period of this study resistant vulgare or common wheats were unknown. The development of rust resistant strains was accomplished by obtaining resistance from the emmer group and by combining this resistance with the desirable agromonic characters of vulgare or common wheats through a series of crosses and selections.

Much remains to be known about rust resistance in wheat but many problems have been solved. Some of the steps leading to our present knowledge may be cited here:

1. The mode of inheritance of particular types of reaction to stem rust have been determined both in the greenhouse and in the field. The most important and practical result of these studies is the conclusion that resistance to all races of stem rust of wheat in the stages from heading to maturity may be dependent upon only a single or a few genetic factors.

2. The pathogen causing the disease is composed of numerous forms, which we call physiologic races that can be identified by their manner of reaction with a series of wheat varieties and species known as differential host, this separation being made primarily on the basis of seedling reaction. For example, a wheat variety resistant to a particular race of rust in the seedling stage is resistant to this same race in all stages of plant grovbh under field conditions. Physiological resistance Ain the seedling stage is of such a nature that wheat may be immune from one and susceptible to another. An illustration of that of Kanrod wheat and some hybrid derivatives having it as an ancestor are immune from certain races and highly susceptible to bothers. This knowledge explains the reason why Kanrod wheat and derivatives may be highly resistant in one season and highly susceptible in another* A knowledge of the cause of resistance has been of importance. Thus the resistance of Kanrod is physiological and acts only against particular races of rust. A second type of resistance under field conditions to many races of rust as the plants approach maturity, called mature plant resistance, appears to be dimply inherited. The exact cause of this type of resistance is unknowns. Some have suggested that morphological and functional causes may be responsible. Others have given evidence indicating that this dosnit seem to be the explanation. Mature plant resistance is inherited in some cases in a simple Mendelian manner. Its has been learned also that extreme conditions of environment may cause an apparent breakdown of resistance to a particular disease. For example, a plant genotypically resistant to stem rust, if infected with loose smust, may be completely susceptible to rust. This conclusion seems essential in a logical viewpoint of disease resistance in plants. No one expects that a potentially high-yiolding variety will give high yields under unfavorable conditions. Extreme conditions of environment may strongly modify reaction to disease by modifying the charac ter, that, under normal conditions, is responsibly for the resistance to that particular disease.

Another variety wheat, Thatched, which was first introduced in the spring of 1934 has been one of the most widely Brown stem rust resistant cheats being the majors sparing wheat grorn in the eastern and central section of the spring-wheat areal. It .is also extensively grown in Canadian provinces whore steam roust has been severe. It withstood in excellent fashion the, stem rust epidemic of 1934, 1937 and 1938 when susceptibly varities of spring wheats were severely injured. Thatched excels in yielding ability, strength of straw, and milling and baking quality but is somewhat less satisfactory in weight per bushel than some other varities, party because of its small size of seed and its susceptibility to scab and leaf rust. The latter disease was epidemic in 1938 in the spring-wheat area.

I should like to use once other example of the progress that has been made in the breeding of wheat. McFadden in 1930 was the first breeder to develop common wheats having near immunity to stem rust. He produced two wheats Hope and H44, with excellent resistance, or, as I said practical immunity to those diseases. Neither of those wheats, however, was entirely satis factory in other characters. The resistance of Hope and H44 to all rust race in the field under normal conditions in North Ame rica is dependent upon one or two major genetic factors for resistance. Most of the more promising new spring wheats have Hope or H44 in their parentage. Many plant breeders develop varieties and strains which are highly resistant or almost imm une to diseases but are backing in other desirable characteristics. It is presumed that this same difficulty will be, if it has not already in some cases, encountered by plant breeders and geneticists who concern themselves with the problem of improving forest trees.

I should like now to comment somewhat briefly on. the progress that has boon made in corn breeding. Several years ago the viewpoint was expressed by various writers that corn hybrids for different- regions of the corn bolt would have far-reaching effect on the agriculture of the United States.

The hybrid, Burr-Leaming, was first distributed in Connecticut in 1922, but the acreage grown of his hybrid was very small. The first distribution of hybrids in the corn belt occurred from 1932 to 1934, and in 1938 and 1939 from 15 to 25 million acres were planted to hybrid corn, and increased production during this period of from 100 million to 150 million bushels of corn over what would have been obtained if hybrid corn had not been available. Many agronomists be1ieve that there will continue to be a rapid increase in the use of hybrid corn in the years to come until the greatest part of the acreage of corn in the United States is planted in hybrids. As a matter of fact, we have already reached this stage in the corn belt - in many states from 95 to 98% and in some, I suspect, today approach 100%. In the southern region progress has been somewhat slower in the development of hybrid corn. It is not because, however, that our research agronomists, geneticists, and plant breeders have not concerned themselves with this problem. As a matter of fact at several of the Experiment Stations in the southern region hybrid corn breeding programs were begun between 1920 and 1925. We have in the southern region, however, somewhat more difficult problems and conditions than in the case of the corn belt. This is the reason that the development of corn hybrids in the south has been somewhat slower. For example, in the southern region the problem of insect control, particularly the weevil, has been most difficult to deal with. It is a fairly simple matter for a corn breeder to develop a hybrid that will give exceptionally good yields that will, as a matter of fact, out yield by 25 to 30% that of open pollinated varieties. However, we find that to get satisfactory resistance to the ear rots as well as stalk and leaf diseases and to produce a hybrid with satisfactory standability is a most difficult job. Widespread interest in hybrid corn is due primarily to the superiority of hybrids over normal varieties in a number of characters.

Although higher acre yields are important, other improvements as I have already indicated are equal and perhaps of even greater value. Ability to withstand lodging, for example, and resistance to smut, car rots, stalk rots, as well as insects is of major importance. The development of drought resistance has been studied very much, particularly in the corn belt area and much remains to be accomplished on this problem.

In the development of hybrid corn Mendelian principles have been used directly. A standard technique of breeding has been developed based on the direct application of the principles of genetics. Intensive studies of inbreeding and cross breeding were started by E. M. East at the Connecticut Agricultural Experiment Station and G. H. Shull at Cold Spring Harbor in 1905. Many investgators have taken part in studies of inheritance in maize, The fundamental principles have led to a sound basis .for scientific improvement in corn, a field in which a considerable number of investigators devote all or part of their research efforts, Some of the more important principles leading to the present methods,of corn breeding I would like to mention here, although corn breeding is not directly analogous to the breeding of forest trees. Nevertheless, there is much in common, particularly from the standpoint of reproduction. As you know, in the case of corn 98 to 100% of it is cross pollinated and while I am not too familiar with this I understand there is great similarity to pines.

I should like now to mention some other important principles which have led to the development of present methods of corn breedings:

1. Continued self-pollination in corn leads to the production of relatively homozygous types that are in general less vigorous than normal corn. Crossing inbreds restores vigor. Some F_1 crosses are more vigorous than normal corn; others are less so.

2. Crosses between inbreds are difficult. to use in commercial seed production, since the yield of seed per acre is low. This difficulty has been overcome by using for commercial production crosses between single crosses.

3. Hybrid vigor in corn ad in other crop plants has been placed on a definite Mendelian basis. It is a result of partially dominant growth factors. Many genes are involved in growth and vigor, and consequently linkage makes it difficult to combine all of the desirable genes in one inbred line.

4. Some inbred lines have much better combining ability than others when tested in comparable crosses. By crossing a group of inbreds to be used in a definite breeding program with a variety and by testing the inbred-variety crosses in yield trials the better combining inbreds can be isolated and the loss desirable discarded. As a matter of fact, this method has been widely used by corn breeders.

5. The combining value of inbred lines in a double cross can be predicted from yield trials of the appropriate single crosses.

6. The case of commercial production of double-crossed seed is dependent to a considerable extent upon the vigor of the inbred lines as well as the yielding ability of the single crosses used in the double cross. Improved inbred lines of corn can be bred by the same breeding methods as used in the production of improved varieties of self-pollinated plants, although it is necessary to control pollination by appropriate selfing and crossing in carrying out the program. This obviously would be true in the case of pines.

7. The principles of corn breeding that make possible the utilization of hybrid vigor are dependent upon an understanding of genetic principles and their application of corn breeding. This knowledge has made possible to a considerable extent the standardization of corn-breeding techniques.

I should like now to refer to some of the progress which has boon made in the breeding of improved varieties of oats. There are 3 important diseases of oats. They are stem rust, crown rust, and smuts. Resistance to disease, therefore, as well as resistance to cold injury are two things which are emphasized very strongly in the breeding work on oats. Of course there are other problems such as the stiffness of straw. This has come into prominance in recent years because of the fact that the most of our oats as well as other types of small grain are presently harvested with combines. Therefore, it is necessary to leave the material in the field until it is sufficiently dry for thrashing.

Crown rust, for example, is one disease which has been singled out and worked on by a large number of plant breeders. Although some varieties have long been available which show some resistance to crown rust the introduction of Victoria from South America and Bond from Australia have furnished a basis for breeding of resistant varieties since both Bond and Victoria are resistant to many races of crown rust, By using Victoria as one parent in crosses with susceptible varieties Smith, in 1934, concluded that resistance was a partial dominant in F1 However, infection made it impossible to decide the number of factors involved. Stanton, later in 1936, indicated a single factor pair with resistance dominant. Inasmuch as good success was obtained by using Victoria as one of the parents, breeders generally throughout the country obtained satisfactory resistance to practically all of the physiologic races of crown rust. Everything seemed to be moving along nicely until a few years ago a disease known as blight or Helminthiosporium Victoria came into the oat area. It was found then that the now hybrid oats of Victoria origin wore extremely susceptible to Helminthiosporium. This made it necessary that breeders seek out new germ plasm for resistance to Helminthiosporium. While they were doing this it was necessary to dig out some of the old varieties of oats which we had grown several years ago because these happened to carry satisfactory resistance to Helminthiosporium. To make a long story short, fairly satisfactory progress was made, in a few years in the development of varieties having satisfactory resistance to Helminthiosporium because of the wealth of genetic material which was in the hands of the breeders. Then when it looked like we had Helminthiosporium and crown rust licked, race 45 of crown rust came into being which was a new physiologic race of rust and this new race did tremendous damage to a large number of varieties which were in rather general production. At this time now, oat breeders are generally emphasizing resistance not only to these diseases which I have mentioned but are giving particular attention to the development of varieties which are resistant to the more important physiologic races of rust as well as smut. The smut problem was fairly easy to lick. It wasn't difficult for the br eeders to find strains or species of oats which carried satisfactory resistance to smut. As a matter of fact the Coker Pedigreed Seed Co. along about 1930 or 32 had developed oats with excellent resistance to smut.

Thus far, I have confined my remarks rather generally to the end products of plant breeding research. These ccntributions didn't just happen by chance. As I indicated earlier the science of plant breeding is based upon the fundamental biological sciences. I would like, therefore, at this time to emphasize the need for the accu mulation of certain fundamental information. By this, I mean developing a program of basic research in forest-tree genetics, which to the layman might not appear to be of any practical value, but will furnish the storehouse of knowledge upon which future forest-tree breeding programs may be developed. The reason for this has been pretty well indicated in certain crops and crop breeding programs. For example, the work of Beasley in interspecific hybridization of cotton which was pure science and which furnished the foundation to develop practical breeding programs to increase fiber strength is an excellent example of the point which I am trying to make. Dr. Beasley was interested from a fundamental point of view of the origin or development of our so-called American upland cotton. Much had been written by scientists relative to how this American upland type originated. Dr. Beasley in his work made a very careful cytological examination of the chromosomal complement of a large number of wild as well as cultivated species of cotton consisting of the old world types having 13 pairs of chromosomes as well as the new world forms illustrated by the type American upland having 26 pairs of chromosomes. To make a long story short and not to take up too much of your time here with details, I might say that upon a cytological examination Dr. Beasley found that the American upland chromosomal complement could be divided into two parts. One part or genome as it is commonly called consisting of 13 pairs of chromosomes had upon observation considerable similarity to one of the wild 13 chrormosome American cottons. The other half of the genome had certain appearances which led Dr. Beasley to believe that these 13 chromosomes were very similar to one of the Asiastic species of cotton. Dr. Beasley, therefore, attempted to hybridize the wild American with the Asiastic 13 chromosome cottons. This, he found difficult to do but was successful finally in accomplishing a cross. He was able then by the use of colchocine to double the chromosome number of the new hybrid which was found to be perfectly normal and fertile. He studied extensively the chromosomal behavior of this synthetic hybrid having 26 pairs of chromosomes which is the same as American upland cotton. He found, for example, that the behavior of the chromosome in the synthesized hybrid was for all practical purposes identical with that in the normal American upland cotton. This gave extremely strong evidence that this is the manner in which American upland cotton originated. Dr. Beasley reasoned, therefore, that on the basis of chromosomal behavior in the synthesized hybrid, that it should therefore cross readily with American upland cotton. He was able, consequently, to make the crosses at will between American upland cotton and the synthesized hybrid and without laboring the point further this, while the approach was one of pure science led to what is accepted to be, by most people, an explanation of the origin of American upland cotton. Other work of a fundamental nature which has been extremely productive might be mentioned. For example, the work of Reeves and Mangledorff with regard to the origin of corn and how the genetic and cytogenetic knowledge contributed by them is used as a basis for the improvement of corn.

Returning again to cotton I should like to point out one or two things which are receiving major emphasis now. The work of Beasley opened up a new era for the cotton breeder. It made available material which he, up to that time had not been able to use in a practical breeding program. With the development of the passage of the Research and Marketing Act in 1946 and the implementation of a regional research program on cotton genetics there has been developed a project which emphasizes the genetic and cytogenetic approach to the problem of cotton breeding. Research agronomists have been able to accomplish gene transfers from wild cotton into upland types and we are at the present time in the process of developing new varieties of cotton which may not yield appreciably more than some we now have but which have fiber of a tensil strength greatly beyond that which has ever been known in present day cotton. Some of these desirable geness or blocks of genes have been obtained from wild species which to the ordinary person would never have been thought to have anything of a worthwhile nature in them. In the case of cotton we not only have varieties which have good resistance to fusarium wilt, bacterial blight, angular leaf spot, and a number of other disceases but we have varieties of cotton which are far superior in regard to spinning performance than any that we have ever had to date. Breeders now are beginning to give consideration to the breeding of varieties of cotton, the fiber of which will be particularly suited to specific end uses.

I have had the opportunity of talking with Mr. Dorman and observing photographs of various selections of pine trees that had been made and also various hybrid combinations which to me indicate hybrid vigor of a magnitude comparable to that and perhaps even greater than we have been accustomed to thinking in terms of corn and some other crops which have demonstrated excellent heterosis or hybrid vigor. I believe therefore, that we are on the verge now of getting into a forest-tree breeding program in which we will attempt to emphasize resistance to diseases generally, rate of growth, the time at which trees may roach marketable size, development perhaps of varieties or types of pines which will be used specifically for naval stores. I think, too, that we shall give emphasis not only to the rate of growth and the amount of gum produced from trees but we shall also give consideration to the matter of the quality of lumber and other products that night be made from pine trees.

I should like new to make some observations with reference to some of the problems which I think you people will be concerned with in the conduct of a forest tree research breeding program. First, I assume that it is needless to point out that forest tree genetics are no different in principle than the genetics in any other organism and that the prcgram, therefore, initiated for the purpose of improving trees should be based upon sound gene tic and plant breeding concepts and theories.

As a layman, from the standpoint of the group assembled here today, I would like to say that it is encouraging to me to note that the public generally is now looking upon our timber resource with much more interest than has been demonstrated formerly. For example, many people are aware of the fact that a large proportion of the land not only in our state here but in other southeastern states is occupied by timber. Furthermore, many farmers now are becoming concerned about protecting their timber resource from fire and other ravages and with the assistance of forestry personnel, thinking in terms of managing their tracts and marketing their timber in a manner which will bring them the most income from their woodland, I believe, therefore, that now is the time at which we should attempt to initiate a good sound forest tree breeding program and to begin with, inasmuch as the pine is a species which is perhaps more widely grown and contributes more from the standpoint of lumber byproducts, that a good species to begin with would be the pine. Of course, one reason why many people have not become so interested in the breeding of trees and in the planting of trees, and in reforesting some of our gullied eroded land, is because of their short-sighted viewpoint. Many people assume the attitude that, well, this is a long range program and is something that will extend quite beyond my lifetime and therefore I'll let somebody else concern themselves with this problem. During recent years as I have already indicated to you, people now are beginning to do somewhat more long range planning than has been true in the past. Obviously, I am not in a position to suggest to such a group as this what a forest tree breeding program, should be like. There are other people on the program hero who are in a position to discuss intelligently what a forest tree breeding program is like, some of the problems that will be confronted and some of the needs personnel-wise, material-wise, and financial-wise, in the conduct of such a program.

Im speaking of the program, I am glad to see provision has been made for detailed study on some of the fundamental problems by 4 committees. For example, you have a committee to give consideration to geographic strains, another committee on natural variations and selection of superior phenotypes, another committee concerning itself with the stimulation of seed production in superior trees and then anothor committee on hybridization. These committee assignments, I believe, cover the major problem areas that you should concern yourselves with at the present time. Having spent some years as an agronomist and a plant breeder, I am familiar with a number of the problems with which a plant breeder becomes involved. And the problems have certain common characteristics regardless of the crop in question. I mentioned to begin with some of the tools that the plant breeder has used and which have been responsible for his increased productivity. I mentioned genetics, cytolcgy, and statistics. In recent years plant breeders and geneticists for that matter have concerned themselves very much with the field of statistics or sometimes referred to as biometry. There are a number of reasons for this. In the first place, genetics is a science which is based or predicated pretty largely on mathematics, ratios, and so on, and we have had some new tools placed in the hands of geneticists and plant breeders in recent years by mathematicians which make it possible now for the plant breeder to fractionate or break down the total variance of a population into its various component parts, that is, that which is due to environmental effects and that which is ascribable purely to hereditary factors. This has enabled plant breeders in recent years to be, as I have said, much more productive. In the last 15 years or so, progress in plant breeding has not boon so spectacular as it was in former years. As a matter of fact, most of the problems with which the plant breeder is faced today are complicated from the standpoint of inheritance. They are commonly referred to as quantitative factors, and therefore are much more difficult to deal with and to get into a fairly stable condition, genetically, than is true of a situation where you have only one or two or three genes.

In addition to the necessity of a complete knowledge of the genetics of the species involved, it is necessary to develop methods of making crosses, handling, and growing out material from crosses and selections, etc. Equally as important from the standpoint of plant breeding is a good efficient method of testing progenies which are isolated either by selecticn or progenies which have been originated as the result of hybridization and subsequont selection. And a system must be developed for growing and testing the F_1 and F_2 back cross and subsequent generations. This is just as important as making the cross because a good job must be done in testing the selections in order to make the best use of the hybrid material. Evaluation of material is one of the most important phases of breeding. No doubt every breeder has thrown away valuable material because of inadequate testing. Conversely, material of questionable value is carried for the some reason. The breeder must have tremendous numbers in order to secure all possible genotypes of value. For this reason you must discard lots of materials. The system of testing should be as good as possible so that he can do an effective job in evaluating progenies. At the same time the breeder must be abreast of the times and be able to predict segregates and strains of possible future value as well as of immediate importance. Thus, it is seen that the breeder must be well trained, persevering, observant in his habits. Plant breeding is no longer looked upon as an art and entrusted to the lucky guy who happens to be at the right place at the right time. In conducting a testing program it is necessary to use a design that will be efficient in measuring the factor or factors or variables on which it is designed to obtain data. I shall not attempt here to got into a discussion of experimental designs. I would however, like to point out that as we initiate and get a tree brooding program under way that it will be necessary to provide facilities for the testing of a large number of seedlings in sufficient number and with sufficient replication so as to measure differences of economic value. With other crops and I am sure it will be equally true in the case of forest trees, it is necessary to conduct such performance tests under conditions where it is anticipated that the new strain for hybrids may be grown. This makes it necessary to, give careful consideration to the selection of sites for the conduct of such performance tests. Inasmuch as a forest tree breeding program will involve the handling of genetic material which will have regional potential promise it will be necessary in your case, as it has been with agronomists in the case of plant breeding to plan a cooperative testing or performance program with personnel in the several southeastern states and also to take into consideration the variation of soils and limate conditions which occur in the different states. This will be necessary because with the large number of selections or strains, varieties or hybrids that will ultimately come out of the breeding program they of necessity will have to be tested under a good cross section of conditions, which are typical of the area in which it is contemplated that the species may be grown. Of course, the number of seedlings that will be handled in such a testing program can be materially reduced by the development and utilization of greenhouse and nurseries at selected areas. Take for example the technique which is now used by cotton breeders as an example. Particular attention, as I cited a while ago is now given to fiber strength in cotton breeding. There has consequently been developed fiber laboratories at most of the experiment stations where cotton breeding research is under way. The cotton breeder, therefore, has technicians at his disposal who are in a position to use machines and instruments which have been developed, in recent years so that he can get a good estimate of fiber properties of several thousand selections which he may make in a given season. On the basis of these data he is in a position to eliminate, on the basis of fiber properties, a large percentage of his selections without even having to go to the trouble of growing them. With such a facility a cotton breeder, therefore, has pretty good assurance that any selection which he makes in the field and which passes satisfactorily his criteria for fiber properties will ultimately be useful in his breeding program. Those strains or selections surviving the testing program in the cotton fiber, laboratory are grown in the field under field conditions for the purpose of observing agronomic characters and resistance or susceptibility to insects and diseases. Those which survive 2 or 3 years testing under field conditions then are multiplied and put into a new strains test. This new strains test is planted at several locations out over the state. Material, which appears to hold promise in these new strains tests are put into what the breeders call advanced strains tests. At this stage of the breeding program material is exchanged by the breeders in various cotton growing, states. This makes it possible for the breeder in the given state to get a good idea of how widely his strains might be adapted. Strains which appear to hold good promise in the advanced strains test are then put into a commercial test in which they are compared with commercial varieties all across the belt. It occurs to me that such a testing program will have to be developed in the case of forest trees. The difficulty that you will encounter is the fact that it will take quite some years later to get the data from forest trees whereas it can be obtained on an annual basis from field crops. In regard to this, however, I venture to predict that it will not be too long until techniques will be developed for estimating the quality of trees that may be expected from the standpoint of its use as a source of pulpwood, lumber, and for naval stores production. In the case of cotton we have established a high degree of correlation between 5 to 6 cotton fiber properties and spinning performance. So it is a very simple matter to measure these fiber properties in the laboratory and when they are known for us to then predict spinning performance. I believe that such will be possible in the case of forest trees.

In conclusion, let me say again that I appreciate very much the opportunity of being with you here today and of saying something to you which I hope has been of interest. I am sure, however, that I shall receive, while I am with you today, more than I have been in position to give you. Person ally, I think that the purpose of this meeting holds much promise and I believe, as I have already indicated, that we have reached the stage or point where some research must be initiated in the field of forest tree breeding in the southern region and which I am sure holds as much promise in this field as in that of any other.

Perhaps unwisely so, but I have nevertheless purposely avoided being too technical in my presentation. I would, however, at this point like to reemphasize something which I mentioned earlier. That is, in order for a forest tree breeding program to be productive it is going to necessitate the close cooperation and work of foresters, geneticists, cytologists, physiologists, as well as people in many other specialized areas. I am sure also that you people realize that in order to put the program in forest tree breeding over, that the public must be made aware of the potential benefits to be derived from such a venture. I am confident that the people of the industry realize the opportunity which lies ahead in this field and I am sure that they, along with others of us who represent public institutions and agencies of the Government, want to exercise every possible effort in order to get a good forest tree breeding program initiated, one which is well planned, and one which can be put on a sound basis, sufficiently financed over a period of years that will enable us to be productive. As I see it, we can no longer take for granted our timber and woodland resources of this country and consider them as expendable without regard to replenishing the species.

In conclusion, I should like to express my very keen interest in and the excellent opportunity which I feel exists in the development of a good forest tree breeding program. I think that it should be obvious to anyone who thinks about the problems involved in forest tree breeding should realize that there are just as great a possibilities for contributing to the national welfare with respect to this crop as has been demonstrated with corn, wheat, oats, cotton, as well as horticultural crops, a few of which I have tried to mention to you here today.

I hope very much that this meeting will represent the nucleous or beginning of a movement which may culminate in the development of a good forest tree breeding program because I have already indicated, we are devoting a larger percentage of our land to forest trees than any other single use. It also provides a large share of the gross income of the farmers of the southeastern states. Why then, should we not become concerned about making this resource more productive just as we have become concerned about the breeding of superior varieties of crops, breeds, types, classes, live-stock.

Thank you.