GRAFTED SEED ORCHARDS IN THE SOUTH

by

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INTRODUCTION

At the last meeting of the Southern Forest Tree Improvement Conference in New Orleans two years ago, we reported to you the activities of the forest genetics program at the University of Florida. At that time, we were busily engaged in the selection of superior trees. During the two years since then, hundreds of superior trees were selected, ten thousand grafted plants were made with materials from the selected trees, and 15 seed orchards were established in Florida, Georgia, South Carolina and Alabama (fig. 1.).

The credit of this accomplishment is largely due to hundreds of enthusiastic foresters of the eleven pulp and paper companiesl/that participated in this program. It was through their effort that the superior trees were selected. It was through their effort that the seed orchards were established and maintained. Seed orchards have also been started by other institutions in the Southern states (Hargreaves et al. 1955). We will limit this discussion to our own experiences.

THE SUPPLY AND DEMAND OF SEED

There had been an increasing demand for pine seeds during the last decade, in which large scale planting was carried out on an extensive scale in the Southern states, In round figures, Florida planted approximately 100 million pine seedlings last year, and Georgia planted about 120 million. Nearly all of them are slash pine (Pinus elliottii) and loblolly pine (P. taeda). The figure for the eleven Southern states as

Brunswick Pulp & Paper Company, Brunswick, Ca,
The Buckeye Cellulose Corporation, Foley Fla.
Container Corp. of America, Fernandina Beach, Fla.
Gair Woodlands Corporation, Savannah, Ga.
Hollingsworth & Whitney Division, Scott Paper Company, Mobile, Ala.
Hudson Pulp & Paper Corporation, Palatka, Fla.
International Paper Company, Southern Kraft Division, Mobile, Ala.
Rayonier, Inc., Fernandina Beach, Fla.
St. Marys Kraft Corporation, St. Marys, Ga.
St. Regis Paper Company, Jacksonville, Fla.
Union Bag & Paper Corporation, Savannah, Ga.

a whole is close to 700 million (Cossitt).

In the thirties and the early forties, a large portion of pine seeds used in the South was supplied by Brownie Wilder. His seeds were collected from a relatively restricted area around Lake City in Northern Florida and adjacent Southern Georgia. The shortage in the seed supply was most keenly felt in the past two or three years. There was an almost total failure in pine seed crops over most of Florida and Georgia at a time when the demand for pine seed was the greatest. To meet the enormous demand of seedlings for plantations, state and private nurseries were forced to procure whatever seeds were available. Conditions did not usually permit them to make selections with regard to the geographic origin of the seeds and the qualification of the seed trees. A considerable portion of the slash pine seeds were collected from a relatively restricted area in Southern Georgia around Homerville. This was one of the few areas in which slash seeds were available in commercial quantities. Genetically this practice is exceedingly significant. Probably never before in human history has the genetic constitution of a tree population been changed by artificial means on so large a scale in so short a time by plantations over extensive areas throughout the Southern states with seedlings from restricted geographic origins. The serious consequences will be evident in years to come.

The capacity of seed production in a seed orchard of grafted superior trees is not known. From the experiences of the 13- to 16-year-old plantations of slash and loblolly pines in Australia planted at 30 by 30 feet spacing (Florence et al. 1956), we can reasonably expect an average of approximately 24 pounds of seeds per acre for slash pine and 33 pounds per acre for loblolly.

If we figure 14,000 seeds per pound for slash and 18,000 seeds per pound for loblolly (U.S. Forest Service 1948) and the viability is assumed to be 75 percent, then we need approximately 300 acres of seed orchard for slash pine or approximately 200 acres for loblolly pine for every 100 million viable seeds.

The 14 seed orchards established in the last year vary in size from two to seven acres. This initial attempt will yield valuable information for the establishment and management of seed orchards on an extensive scale. The 14 seed orchards are scattered in four states. Besides the model seed orchard of the University, there are eight seed orchards in Florida, four in Georgia, one in South Carolina and one in Alabama in the vicinities of the following localities:

Florida: Perry (Buckeye), Yulee (Container, Rayonier), East Palatka (Hudson), Mariana, Bronson and Madison (International), Cantonment (St. Regis).

Georgia:	Brunswick (Brunswick), Statesboro (Gair), Denton (International), Egypt (Union Bag).
South Carolina:	Georgetown (International).
Alabama:	Alabama border west of Cantonment (International).

With the exception of the seed orchard in Gainesville which for experimental purposes was planted at four different spacings from 25 by 25 to 40 by 40 feet, most of the other seed orchards were planted at 30 by 30 feet spacing. This is approximately 50 trees to an acre. For a seed orchard to produce 100 million seeds, according to the above calculations, 15,000 grafted plants are required for slash pine or 10,000 grafted plants for loblolly. We have not solved all the problems related to the grafting or other means of vegetative propagation of selected pines. However, so far as propagation of slash and loblolly pines by grafting is concerned, we are confient that a simple technique and schedule could be developed that would make the propagation by the tens of thousands just a routine matter. We will discuss briefly what we learned by experience in the past years.

THE PROPAGATION OF SUPERIOR PINES.

We made a little over 10,000 grafts in the past three seasons: 437 in the first year (1954-55), 4172 in the last season (1955-56) and 5491 in this season (1956-57). The majority of the grafts were slash pine grafted on slash stock, with a small percentage of loblolly on loblolly or slash stock. The overall percentage of successful grafts for the last season is 64 percent; and the figure for this season is 35 percent. In order to find out the best method and the best time for this operation, several methods had been tried in the first year from December to June. We are glad indeed to report this increase in success over the 1954-55 season when the percentage of successful grafts varied from 21 percent to less than 1 percent.

On more than one occasion, we were approached by interested parties inquiring about the "secret" of our humble success. A detailed record for all the steps of our operation had been meticulously kept from the time the cuttings were collected from the selected trees until the grafted plants were ready to be shipped out for outplanting in the seed orchards. We tried not to make the same mistake twice.

The most important single factor affecting the successful grafting union is beyond doubt the condition of the scion and the stock. A major improvement could be made in the survival ratio by not insistently using dead twigs on dying stocks.

However, all the cuttings used in the past years with only rare exceptions were in apparently good condition. Nevertheless, the percentage of successes varies considerably. Obviously, a successful

graft union depends upon a number of factors. Among the factors examined are the age of the tree, the geographic origin, the date of grafting, the grafter, the cold storage of the scion, the type of bags used, the duration of shade, the presence of male or female flowers or conelet, the age and condition of the stock, plant hormones, insecticide, fungicide, pruning, and fertilizer.

Even without the help of statistical analysis, we know for sure that among the factors examined, one factor was most significant, in our case at least (Fig. 2). The lack of it, nearly ruined our whole operation. This was the regular spraying of insecticide. The overall percentage of successful grafts for the last season was 64 percent. However, of the 101 clones (1738 grafts) that had not been sprayed with insecticide at an early stage, only forty-two percent were successful. The 169 clones (2434 grafts) that were under regular spraying schedule had a survival percentage of a little over 79 percent, which is close to this season's result.

We found the best result was obtained with fresh material, but cold storage of the cuttings, at above freezing temperature for a short duration of time, which is almost inevitable in large scale operation did not seem to have a serious deteriorating effect on the scions. We have conducted an experiment on the cold storage of cuttings. Successful grafts have been obtained from dormant cuttings that have been in cold storage for more than three months.

One additional factor is so obvious that it is too often overlooked, namely, the man who did the grafting. The bulk of our propagation work was carried out by two men. Each of them used materials of approximately equal number of randomized clones from each of eleven groups of selected trees. The performance of Man A (111 clones, 1687 grafts) was consistently superior to Man B (107 clones, 1632 grafts.) (Fig. 3).

The grafting of superior pines on seedlings in the nursery and in the field, a practice which we carried out only on a limited scale, had yield comparable results as the grafting on potted seedlings. In our program the shipment of thousands of grafted plants to seed orchards in four states, and the free exchange of materials between the eleven participating pulp and paper companies necessitate the use of potted stocks for easy handling.

According to our working schedule, the polyethelene bags are gradually released at the end of the sixth to the eighth week after the grafting. Most of the mortality occurs before this critical period. Two to four weeks after the removal of the bags, the plants are moved from the lath house to the open field under regular irrigation; and they are now ready for out planting in the seed orchard.

THE DESIGN AND ESTABLISHMENT OF SEED ORCHARD

Under conditions generally prevailing in the southeastern states, grafted plants of superior slash or loblolly pines are ready for out-planting at the end of the tenth to the twelfth week after the grafting. The heavy spring work schedule usually delays the out-planting of grafted plants to a time not ordinarily considered as optimum for transplanting. The time for out-planting has been a matter of controversy. However, we are fully convinced that there is everything to gain by setting out the grafted plants in the seed orchard as early as possible. In the season just past grafted plants were shipped out from late July through August. Due to the god ground preparation and the great personal care exercised by the foresters in charge of the seed orchards, good results were obtained, even in transplanting during the summer. With the exception of two seed orchards which lost close to 20 percent, the mortality in transplanting in all the other seed orchards were from 5 percent to 10 percent. Better results are expected for the current season. All the plants will be shipped out and transplanted at regular weekly intervals from March to the early part of May.

A few major decisions are essential prior to the planting of the seed orchard. The decisions include (1) the width of the pollen barrier, (2) the design of the plantation, and (3) the number of clones to be included in each orchard. These matters involve information on pollen dispersal for the southern pines and theoretical consideration regarding the establishment of a seed orchard.

To get the pollen dispersal information, we collected series of pollen slide at various known distances from the pollen source. Preliminary examination revealed that even at a distance of one mile from the nearest pollen source, a few pollen grains could still occassionally be found. However the number of pollen grain fell off so drastically within 400 feet of the source that pollen barrier of this distance was recommended for the seed orchards.

Nearly all the selected trees used in the seed orchards are represented in the plantations of the University. They serve not only as a study on the establishment and management of seed orchards but also as a repository of selected trees for genetics research. The number of clones included in the other seed orchards vary from 15 to 30. At the end of this season (1956-57) each seed orchard will have materials from a total of 30 to 50 clones. The number of grafted plants for each clone vary considerably. On the average, each clone is represented by approximately 8 to 10 grafted plants.

The simplest design for the arrangement of the clonal materials in the seed orchard is usually the best for general purposes. A completely randomized design was used when the plants were few in number and the area of planting limited. A randomized block design is very desirable when more plants are available and all the clones are nearly equally represented by grafted plants. In this case, the plants are divided into blocks, each of which includes a complete set of the clones

randomly arranged. The chance ofinbreeding is minimized and the even dispersal of pollens from all the clones throughout the seed orchard if facilitated.

The number of clones to be included in a seed orchard is a matter of basic consideration. It has been definitely shown from the result of our controlled pollination that selfing is detrimental in the southern pines. Gustafsson (1949) in his discussion on the genetic principles of seed orchards to avoid the dangers of inbreeding, considered 20 to 30 clones as a minimum.

On the other hand, the need for uniform pollen distribution in the seed orchard places a maximum limit on the number of clones in a given seed orchard. This is not a problem in a good pollen year. Plantations in Australia (Florence et al. 1956) show, however, that in a poor pollen year the cone yield of trees in a plantation was influenced by the availability of pollen. In a large seed orchard with many clones this means that free access of pollen of all the clones throughout the seed orchard will be very much restricted in a poor pollen year. In Sweden a system of seed orchards for the production of Pinus sylvestris seed has been established for each geographic region. The number of selected trees available is obviously not the limiting factor. However, 25 to 50 clones are recommended to be represented in each seed orchard. (Arnborg 1956).

The number of clones used in our seed orchards was unfortunately not wholly decided on a theoretical basis, but was rather dictated by the materials available which include only the very best of the selected trees. Clonal materials of these seed orchards could be substantially enriched through liberal exchange of cuttings and grafted plants between companies that have forest holdings within the same geographic area.

CONTROLLED POLLINATION OF THE GRAFTED PLANTS AND PROGENY TEST

The selected trees used in the seed orchard are definitely superior phenotypically. The real merit of the tree, however, can be determined only through the progeny test. It is true that the grafted plants in the seed orchard probably will not begin to bear seed in quantity until the 10th year or later. But controlled pollination for the purpose of the progeny test can be made on the grafted plants in the seed orchard within 12 months following the out-planting.

The seed orchards were established in the summer of 1956 with grafted plants made in the winter of 1955 and spring of 1956. A considerable number of the plants produced male and female catkins in the spring of 1957 in nearly all the seed orchards. In one seed orchard, where the plants were very well taken care of and were fertilized with commercial fertilizer, 50 out of a total of 168 plants bore female catkins. All the clones were represented by the flowering plants of this seed orchard. These plants were used for controlled pollination this spring.

No special attention was given to the catkin bearing cuttings or grafting in the 1955-56 season. We did emphasize the collection of cuttings whenever possible from above the lower third of the crown. The thin, short and usually crooked shoots of the lower branches are generally not very successful in grafting. Furthermore, on the assumption that both the male and female "flower buds" which were occasionally found on the cuttings, were unnecessary burdens to the scion, and hence, so the seasoning went, detrimental to the grafting union, the use of catkin bearing cuttings was discouraged. But for experimental purposes and also out of necessity, when not enough non-catkin bearing cuttings were available, a portion of the propagation was made with catkin bearing materials. Out of a total of 4172 plants about 250 plants bore female catkins and 400 plants bore male catkins.

Emboldened by last season's experience, we decided to make as many catkin bearing grafts as possible in this season. Special attention was paid to the female catkins both in the collecting and in the selective use of scion materials. Out of a total of 5491 grafts made, over 400 successful grafts female catkins and over 600 bore male catkins. They were used in controlled pollination. A crop of seed can be expected for the progeny test from the grafted plants 15 to 18 months after they are out-planted in the seed orchards according to this season's working schedule.

This season's propagation started in the first week of November. For most of the selected trees, the season was to early to detect even the earliest sign of female flower bud. Far more cone producing grafts could be made by the exclusive use of female catkin bearing scions which are detectable in spring by small swelings on the side of the terminal bud.

There are distinct advantages in conducting controlled pollination on grafted plants. In this season, materials from over 300 selected trees were all assembled in one lath house. Pollen production could be forced by the manipulation of temperature. Most important of all, the female catkins of the hundreds of selected trees could be inspected with ease at regular intervals and pollinated as soon as they were receptive. It is next to impossible with even the best of facilities for us to hunt out the 300 standing trees scattered in the remote corner of four states, to examine them at frequent intervals, to collect the pollen, and to pollinate them exactly at the time when their female catkins are receptive; and above all to accomplish all these operations within the short breeding season which is variable from year to year, from place to place, and from tree to tree.

For the present stage of our work which involves a large number of clones as a result of the mass selection, utilization of the grafted plants is the only practical way to conduct controlled pollination on this large scale.

Secondly, it was always a painful experience at harvesting time to see that a high proportion of the hand pollinated cones high up on the tree were destroyed by insect, fungi, or rodents (Hoekstra 1956).It is difficult for the hundreds of selected trees in their natural stands to get as much protection and daily care as the grafted plants in the seed orchard under regular irrigation and spraying schedules.

Furthermore, the selected trees, once grafted, could be multiplied by vegetative means almost indefinitely. Within a matter of years, more flowering materials could be found in the grafted plants through repeated propagation than on the selected tree itself. The effect of frequent crop failure and inevitable intervening poor crop years of the trees in the natural stand could be minimized by good seed orchard management.

The Swedish ladder and tree climbing equipment are still useful tools in forest genetics. But more and more cuttings are being collected by high powered rifles which can bring down the desired branch high up in the crown almost at will. It is also true that probably with only some rare exceptions, the cuttings of slash and loblolly pine in the southeastern states can be propagated by grafting with considerable degree of confidence. From the calculation in the section on the supply and demand of seed, 15,000 grafted plants of slash pine on 300 acres of seed orchard or 10,000 grafted plants of loblolly on 200 acres are enough to produce 100 million viable seeds. The production of seed from superior trees in seed orchards to supply the total annual planting in the southeastern states is actually within easy reach.

With our present facilities, 10,000 grafted plants can be made in one season without too much difficulty. However, the superiority of the selected trees has to be proven by the progeny test. At the present, we are hesitant in making more grafts than are necessary for experimental purposes. By the use of controlled pollination on the grafted plants in the seed orchards, enough seeds from the hundreds of selected trees could be obtained for the progeny tests in the next two to three years. The first crop of seed from the superior clones which were grafted and pollinated in the season of 1955-56 will be harvested this coming autumn. We hope the preliminary result can be obtained in time for the next meeting.

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