THE FOREST SERVICE BLACK WALNUT GENETICS PROJECT
A PROGRESS REPORT

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The Forest Service Black Walnut Genetics Project at Carbondale, Illinois, is relatively new. It was made an official project just 2 years ago. Since the emphasis at this meeting is on hardwoods, I thought you might be interested in hearing about our personnel and facilities, the scope of our research assignment, and something about the studies underway.

Genetics is only part of the overall Forest Service research on walnut: We are also doing research on physiology at Ames, Iowa, and on silviculture and soil and water relations in Illinois and Indiana out of our Carbondale office. The genetics, physiology, and silviculture projects complement each other and are therefore closely coordinated; the latest silvicultural techniques are being used in our genetics research plots.

FACILITIES AND PERSONNEL

We have under lease from Southern Illinois University 40 acres for developing a walnut-breeding arboretum. On this tract we have built an irrigation pond and are now equipped with pump, lines, etc., for watering in the arboretum. Almost completed are two greenhouses with an adjoining headhouse. These facilities are shared with the Forestry Department of the University. We also have a small shadehouse, and construction will soon start on a storage building.

On the SIU Campus a new Forest Service Laboratory and Office Building is under construction. It will have laboratory and office space for all Forest Service scientists at Carbondale.

Dave Funk and I are assigned to the Genetics Project; and we expect to eventually have another specialist in the project.

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OVERALL ASSIGNMENT AND COOPERATION

The overall assignment for the Genetics Project is to "learn basic principles and methods needed to produce improved varieties." More specifically, our objective is to provide the basic genetic knowledge required to produce straight, fast-growing, insect- and disease-resistant, high-quality walnut trees of the timber type. Obviously, we need help to accomplish this objective. Research by other institutions will be necessary. We appreciate the fine cooperative relationships that we have had from workers throughout the country and the world, and hope it will continue. We have received fine support from the American Walnut Manufacturers' Association, the Fine Hardwoods Association, Agricultural Research Service (in particular, Dr. J. W. McKay), National Forest Administration, nearly every State Forestry organization in the walnut range, Tennessee Valley Authority, at least 10 universities in Central and Eastern United States, the Northern Nut Growers Association, private companies, and a host of individuals interested in walnut. People in other countries have also been helpful in collecting and sending seeds.

STUDIES UNDERWAY

The Genetics Project can be broken into two main phases--selection and hybridization. Although the phases are not mutually exclusive, I will discuss them separately.

Selection

We have the following studies that deal with natural variation and selection in *Juglans nigra*:

1. Black walnut one-parent progeny study
2. Black walnut seed source study
3. Natural variation and heritability of apical dominance in black walnut

These three broad projects encompass the work we are doing with the native black walnut. The one-parent progeny study was started by F. Bryan Clark several years ago. Seed was collected from 40 superior phenotypes in natural stands in 12 different states. The trees were selected for outstanding timber qualities. All the trees were large and most were mature. They ranged from 16 to 40 inches in diameter (D.B.H.). One tree had a clear length of 64 feet to the first limb. We may never see walnut trees like some of these again, and although we do not know if they are genetically superior, we do not want to take a chance of "losing" any valuable genes. Progeny from these superior phenotypes have been planted in several states, and we are also collecting scion wood for our breeding arboretum. Results from the progeny tests are not yet available.

We started the seed source study in the fall of 1965. Seed was collected from trees in more than 80 natural stands throughout the natural range. The seed was sown in the State nursery in Iowa, in a randomized complete block design, using individual parent-tree progeny (families) as the basic experimental unit. Data were collected on foliage color, insect damage, branch angle, multiple stems, leaf drop, and height and diameter during the first year in the nursery. The data are being analyzed, and results should be published within a year. Covariance analysis was used on height and diameter measurements, using nut size as the covariate. As one might guess, the size of the nut has a lot to do with the size of the 1-year-old seedlings.

We have observed that nut size from an individual tree is quite uniform. Although variation between parent trees (families) was large, nut size showed no pattern over the range of the species. The average nut weight for 70 stands (consisting of 456 families) was 22 grams, and ranged from 12 to 30 grams per stand. The range per family was 5 to 40 grams. The maximum range of seed weight between families within stands was 24 grams.

In the spring of 1967 the seedlings from the seed source study were outplanted at 10 locations in 9 different states. About 20 sources were planted at each location. Although this is a long-range study, with intensive culture we hope to have some meaningful preliminary results in 5 years.

The problem of crooked stems in walnut is well known. In many plantations straight stems are the exception rather than the rule. The reasons for crook are many--wind, ice, insects, deer, spring frosts, winter kill, and probably a few more. We intend to devote a considerable portion of our research effort to this problem.

The work on producing straighter stemmed trees falls into our apical dominance study. We have hypothesized that trees with a high degree of apical dominance will develop straighter steins. It has been shown that apical dominance is due to a balance between auxin and kinin in the plant. At present, we are not working with the mechanism per se, but rather with the morphological characters that develop as a result of the mechanism. The apical dominance phenomenon may be measured by the degree of branch inhibition (bud development), length of branches in various parts of the crown, and the branch angle.

In one of our first experiments, we measured the response (epicotyl curvature) of dark-grown seedlings to unilateral light. There were significant differences between seedlings but no differences between families or sources. Genetically identical pairs of seedlings were used in this work and the seedlings are now being used for studying other characteristics. During the first growing season, there were significant differences in leaf angle between families, and in height-leaf length ratio between sources. No north-to-south variation pattern was detectable. This work is continuing.

A study has been started on the inheritance of straight stems and wide branch angle. We are currently looking for walnut plantations, 10 to 20 years old, on relatively uniform sites, where we will have an opportunity to compare characteristics on different trees. We have located a few outstanding trees with these characteristics but would like to have more. If anyone knows of such a plantation, I would appreciate hearing about it.

Hybridization

Our hybridization work is just beginning. We have one project, an evaluation of progeny from hybrid parents, underway. We have also spent quite a bit of time in developing our breeding arboretum. Seed and scion wood have arrived from many parts of the world.

The hybridization program will not be in full swing until we have flowers produced . But that should not be long. Many J. regia and J. regia X J. nigra hybrids start producing flowers in the second or third year. Our objective in the hybridization program is to produce a straighter and faster growing tree. There is evidence of heterosis in some of the hybrids, and we hope to make some gains through crossing.

The ten species of Juglans and at least nine hybrids now growing in the arboretum are listed in the following tabulation; their origin is shown in parentheses.

J. nigra (U.S.A.)[1/]

J. cinerea (U.S.A.)
J. hindsii (U.S.A.)
J. major (U.S.A.)
J. regia (Russia, France, West Pakistan)
J. boliviana (Costa Rica)
J. ailanthifolia (Japan)
J. sieboldiana (Japan)
J. mollis (Guatemala)
J. australis (Argentina)

J. nigra x J. cinerea
J. nigra x J. regia
J. nigra x J. microcarpa
J. nigra x J. sieboldiana
J. nigra x J. " var. cordiformis
J. cinerea x J. sieboldiana
J. cinerea x J. " var. cordiformis
J. regia x J. mandshurica
(J. regia x J. nigra) x J. nigra

1/ 1. Sources from throughout the range.
2. Progeny from superior trees.
3. Grafted stock from superior timber trees.
4. Named nut varieties with good timber traits.

DISCUSSION

JAYNES - I'd like to direct my comments to Clyde Hunt, since he invited me to make some comments on the chestnut work. I'm glad to hear that he's getting some correspondence on chestnut too; I thought all the letters were being funnelled through Connecticut. This interest that the public has in chestnut can be pointed out by an article that appeared by a free-lance writer and was in the Reader's Digest in 1963. The USDA work was mentioned along with Jess Diller's name and the work at the Connecticut Station. Each institution received over 1000 letters in response to that article. The State of Connecticut deserves some credit for maintaining the breeding and research program on chestnut for over 20 years. As you know this was started by Dr. Graves when he was at the Brooklyn Botanic Garden in 1930. This forest tree breeding project has gone on now- for almost 40 years, but I think you have to admit that not a great deal can be done with just one man working half time, which is the present situation on chestnut breeding. I better just try to summarize in about three statements the present status: (1) we do have improved chestnut clones, and I'll show the picture of one of these tonight; (2) we need better screening methods for blight resistance, and this is one of the problems we are working on; and (3) we need better clonal propagation techniques, which is another aspect that we're working on at the Experiment Station. One other point, chestnut is a good tree in wild-life plantings, and is not being utilized to its fullest extent in this respect. A great deal of work can be done with this genus, and I go along with Clyde, that I would very much like to see more work done, especially by a Federal Agency which can cover a much bigger geographic area than we can as a State organization. I'd be happy to cooperate with anyone who's interested in doing chestnut work.

DORN - For the benefit of the group here, what type of trees are you interested in? Do they have to reach a certain diameter, and if so, how big and so forth?

JAYNES - With respect to the native species and possible blight resistance, we are interested in learning of American chestnut trees within the old native range that have reached a diameter of at least 8 inches. Whether they are blight-free or not is not of particular concern, although we would like to know whether there is an infection on the tree. We do know of large trees, and one of our problems in Connecticut is what do we do with them? (I've got a file and Gerry's got a file, of reports of large American trees.) We've used some of these in our breeding program, but we're simply not in a position to check them all out, especially when they're geographically distant from Connecticut. I know in Tennessee they've looked at some of these trees. We don't have any long-range program of what we're going to do with these, but we want to know about them and we are trying to propagate some of the better ones.

HUNT - I have even toyed with the idea of a non-profit organization to "Bring Back the Chestnut." If I thought it would help I'd write another article for a bulletin or a popular magazine. A plea for funds might even be included. At least we would find out how deep the interest lies. People still write numerous and emotional letters; this might be one method to maintain interest and might move someone toward additional chestnut improvement. I should point out that the Forest Service is not so moved, at least riot presently. Dr. Jesse Diller has retired and apparently so has his project. It is my hope to be able to respond to future inquiries saying, "Yes, the U. S. Forest Service has a project underway to restore the chestnut to Northeastern forests," but I can't even say we are doing anything.

CLAUSEN - I notice that Don Dorn was looking pointedly at me when he brought up the problems of yellow birch, so I feel compelled to say something. I won't promise that I will help you any, Don, but you're right. Age determination is difficult in yellow birch. We have used an electric plane to prepare stem sections for age counts and that helps some. I have no good suggestions for how to get good counts from increment cores.

BOND - Back to chestnut. Isn't the Clapper hybrid the final answer to chestnut research, or are we still trying to improve on this?

JAYNES -- The Clapper chestnut is a very rapid growing, straight-boled tree; however, it has not been tested on other sites and its field resistance to the chestnut blight fungus is unknown.

BOND - Thank you. While I have the floor, may I ask Mr. Bey a question about walnut. We have a walnut veneer buyer in Maryland who also has a hankering for genetics. He says that walnut may be a multiple-use tree. For example, he suggests grafting scion wood from walnut with an exceptionally good grain onto ordinary walnut rootstock, let it grow to a height of 8 or so feet, then graft on to it scionwood from a tree that bears superior nuts. To raise a question, is this practical? Is this in the realm of possibility in the next several years?

BEY - It is certainly within the realm of possibility. Whether or not this grafting approach to get the dual purpose tree is practical, we do not know. Grafting walnut in the field is not particularly difficult. Dave Funk may have a comment on that.

FUNK Just wanted to ask Cal Bey. Do you find any relationship between seedling statistical? size and seed size in your outplanting the walnut, either observational or

BEY - We haven't observed in the outplantings yet; in the first year in the nursery bed, yes. Large nuts produced large seedlings. This was not as high a correlation as I had anticipated. With the range of sizes we had and what you observed from the screen, I thought that the correlation would be very high, but the thing that confounded it was the difference in sources. You see, the smaller nuts from the south would tend to produce larger seedlings than the smaller nuts from the north, and this confounded the relationship and we have not broken it down by individual sources.

JAYNES - Is your seed size based on kernel or kernel plus shell?

BEY - It's based on seed weight.

JAYNES - So you could have a big nut with a very small kernel. Thus total seed weight does not necessarily reflect nutrient reserve available to the developing embryo.

BEY - Very true, but we set up criteria beforehand that the specific gravity must be higher than 1.0 in order to eliminate some of the possibly partially filled seeds, and then we used only seed we figured was filled in our analysis. We couldn't possibly crack-test for this characteristic in this study.

HUNT - As I recall T.V.A. has numerous records of cracking tests and nut weights. I don't know if they made any correlations of early growth with the actual embryo weight. Perhaps King Taft would care to comment.

TAFT - The work that Clyde is referring to was done between 1935 and 1955. TVA was looking for a crop to supplement farm income. With walnut, they were searching for a winner, a variety that would produce easy-to-crack nuts with large kernels. The end product was the Thomas variety. Many studies were made of which two are significant here. In the first, they selected about 250 wild, open-grown walnuts throughout the Tennessee Valley. The trees had to be bearing nuts and an attempt was made to sample the different age and size classes. The total nut crop of each selection was collected for six consecutive years (1940-45). Every year cracking tests were run on a sample of nuts from each tree. The average nut weight and kernel weight for these trees over the six-year period were 16.7 grams and 3.3 grams respectively. In the second test, scionwood was obtained from outstanding nut varieties throughout the walnut range. In addition, local contests were held to select walnut trees on the basis of their nut qualities. Scionwood was obtained from the winners. These two procedures resulted in 90 selections. They were grafted and the grafts planted near Norris. Over a twelve-year period 278 cracking tests were made. In these tests of nut samples from trees selected for nut quality the average nut weight was 20 grams, an improvement of 3 grams or 18 percent over unelected Tennessee Valley trees, and an average kernel weight of 5.1, an improvement of 1.8 grams or 54.5 percent. This selection based on nut quality alone gave outstanding results.

If we find that heavy nuts or nuts with large kernels produce large seedlings, we should add this trait as a selection criteria. This would be particularly true if direct seeding was used. Thus if seed size and/or weight is correlated with seedling size, this would have a definite advantage in plantation establishment.

SCHREINER - In 1935 I was hired by the T.V.A. to start the "Tree Crop" breeding program. The Thomas clone was not a T.V.A. selection, it was an earlier selection of a natural seedling. In 1934 there was a large, producing, orchard of this clone in Bird-in-Hand, Pa.; the Thomas seedlings grown in the Tree Crop Nursery of the T.V.A. in 1934 and 1935 from this seed source were surprisingly uniform in first-year growth-rate.

GABRIEL - My question is to Mr. Bey. You mentioned trees that are 60 feet in height with clean boles. I'm interested in how you find these trees and how you get out to the outer periphery of the crown to do your controlled pollinations.

BEY - The trees have been reported by Industry and Public foresters. We haven't done any controlled pollinations yet. We don't plan to climb the trees; these are high value trees and we do not want to damage the bole of the tree for lumber or veneer.

GABRIEL - How are your scions collected for your grafts?

BEY - We have shot some down with a .22 rifle in the tall trees. In many cases these superior trees that Bry Clark found and used in his progeny study, are being cut now, and as they are cut we get reports (there is a tag at each tree), and we go out at that time and try to salvage what we can as far as collections of scionwood is concerned.

KLEIN - I have a question for Mr. Dorn. How many individuals of a species do you think you should have before starting progeny tests, and about how long do you think it will take to select enough trees for progeny tests?

DORN - The biggest push right now in my area is in black cherry, among the species I mentioned. It looks like one of our limitations in black cherry is getting a seed year. We were planning to collect seed on all the trees that we had selected so far, and in Pennsylvania probably less than 10 percent of those trees will have a collectable crop. Perhaps in West Virginia this year it might be a little better because more of the trees had some blossoms. We plan to make 140 selections in black cherry and start our progeny testing as soon as we obtain seed from 10% to 15% of these trees. Why some trees have seed and some don't is another question; people have suggested it's due to frost, either late spring frost or low winter temperatures. But that seems somewhat unlikely in view of the fact that we find adjacent trees with and without a seed crop. So another problem that needs a lot of work is fruitfulness.

HUNT - I should point out that the black cherry work plan calls for the progeny tests to start in 1966. There are two major reasons for falling behind schedule; lack of heavy seed crops is one and the second is the small number of selections. As Don mentioned the difficulty seems to be to get a busy forester to leave his daily routine to look for and report a tree. Some additional. stimulus is required.

SWAFFORD - In pine trees, we know that some are incapable of flowering and producing cones; do you anticipate the same thing in hardwoods? You are talking about some of your cherry trees not producing seed; maybe you have selected trees that do not reproduce.

DORN - It's possible. I expect that some of these selections will consistently have heavier crops than others, but I've only observed these for one year. There are a few of these trees, a very few, that had been selected previously, but most of them have been selected less than a year ago. But of those that had been selected earlier, we have a very few that had a heavy crop last year, and they have another heavy crop this year, whereas most of the trees throughout the stand have no seeds whatsoever. Maybe some may never have any seed as you suggest. We just don't know at this point.