TREE IMPROVEMENT PROGRAM AT THE CARBONDALE FOREST RESEARCH CENTER

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We are sure that genetics of trees is the same as genetics of corn, wheat, beef cattle, and the red-eyed fruit fly swarming over the bananas in the local market. Thus, we are very fortunate because many basic concepts of heredity are history. The pioneering trails, most of them made with the fruit fly, are now great paved highways to plant improvement. There is a need for the tree breeder to continue to look for genetic concepts but, the greatest need now is to apply known concepts to trees-to put our important species on the highways to plant improvement. We are attempting to do this. However, we cannot get some studies moving because of the lack of certain feeder roads. These side roads are not always concerned strictly with genetics, but frequently with other problems--for example, the physiology of flowering, the development of viable seed, pollination, vegetative propagation, planting, responses to environment, natural variation, and others.

At Carbondale we are building feeder roads that will help put some hardwood trees on the main highways to tree improvement. The studies include field tests of poplar clones; seed source studies of loblolly pine, shortleaf pine, white pine, eastern redcedar, basswood, black locust, and yellow poplar; field tests of pine hybrids and oriental chestnut; studies of pollination and seed development; and studies of environmental-genetic variability.

Two of these studies are being conducted in cooperation with Dr. Margaret Kaeiser of the Botany Department of Southern Illinois University who is doing the anatomical work. Another study is being conducted in cooperation with Dr. William C. Ashby of the Botany Department of the University of Chicago. And, the Forest Products Laboratory is giving us assistance with all of our studies of wood characteristics. Through these studies we hope to locate and help develop better trees for the Central States.

Our early studies and publications were primarily concerned with conifers. In recent years we have started tree-improvement studies with hardwoods. Wd will continue to study the conifers, but our emphasis today and in the future will be hardwoods. Today I will discuss three of our recent hardwood projects--seed development of yellow poplar, fiber length in cottonwood, and clonal tests of poplars.

We began our studies of embryo formation and seed development with yellow poplar. The fruit of this tree is a cone of about 90 samaras. Each samara has the potential of producing 2 seeds, yet on the average, less than 10 percent are viable. We wanted to know why, and whether we could increase viability.

For two growing seasons we made weekly collections of buds, flowers, and fruits. Microscopic sections are being made of this material and we are determining the sequence of events leading to the development of viable seed. We have also made self and cross pollinations and have tested for vegetative development of embryos. At present we can summarize our findings as follows:

There is no evidence of chromosome or meiotic irregularities. In the trees we studied we have found the basic chromosome number to be 19, the same as previously reported by other workers. [1]/

The cones and seed coats will develop to maturity without pollination as previously reported by Wright. [2]/ In sectioning and in germination test , no embryos were found in more than 50 cones from unpollinated flowers. There was no evidence that embryos develop vegetatively in the absence of fertilization.

Development of spore mother cells, the embryo sac and its component parts, and pollen germination appear to be normal. Freshly collected pollen seems to have a high percentage of germination.

We did find differences in compatibility among pollen sources. Pollen from some trees produced a higher percentage of viable seed than pollen from some Aher trees. We also found a high degree of incompatibility between pollen and flowers of the same tree. At present incompatibility is the only reason we can find for the low viability of yellow poplar seed.

But the search is not yet completed. In future studies we will look for reasons of incompatibility and we will search for highly compatible pairs of trees for further studies and for the establishment of seed orchards. Before long we hope to have a fairly complete picture of seed development in yellow poplar.

For our first study of environmental-genetic variability we investigated the fiber length of eastern cottonwood. In Illinois, Missouri, Kentucky, and Indiana we took wood samples from 83 dominant cottonwoods. For each tree, at 4.5 feet from the ground, we determined the average fiber length of every 5th ring from the pith. We measured more than 35,000 fibers. Most of the analyses have now been completed and I can give you some of the results today.

The mean fiber length among trees ranged from 0.85 to 1.25 mm. The average was 1.06 mm.

Mean fiber lengths among rings were highly correlated. For example, the fiber length of the 5th ring can be used to predict the fiber lengths of the 10th, 15th, 20th and 25th rings with standard errors of less than 0.07 mm. Trees with above average fiber length in the fifth year can be expected to have above average length fibers at older ages. This means we can sample wood from 5-year-old trees to screen hybrids or natural trees for long or short fibers. And, for screening trees, it is only necessary to determine the fiber length of one annual ring.

We found the most important conditions affecting fiber length (other than heredity) to be age and diameter (figure 1, 2). The older the tree and the larger the diameter, the longer the fibers. Differences in age

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1/Whitaker, T. W. 1933. Chromosome number and relationship in the magnoliales. Jour. Arnold Arb. 14:376-385.

2/Wright, J. W. 1953. Tree-breeding experiments by the Northeastern Forest Experiment Station 1947-1950. N.E. Forest Expt. Sta. Paper No. 56.

accounted for 44 percent of the variation among trees, and at the average age of 22 years, differences in diameter growth accounted for 5 percent of the variation.

If we assume 10 to 20 percent error, the genetic component of variation is probably between 30 and 40 percent. This is sufficiently high to expect some improvement through selection. If we find a tree with exceptionally long fibers we can expect many of the offspring from this tree to have longer than average fibers. For the trees we studied, the range of genetic variation was 0.26 mm. Clones from this tree should give us an increase in mean fiber length of about 13 percent.

Since heritability is rather high, at least 30 percent, we could make some improvement through a selection and breeding program; but because of the narrow range of genetic variation, progress would be slow and expensive. We need to find longer fibered cottonwoods that can be propagated vegetatively and used for breeding studies. We hope to find some plus trees in future screening tests.

At present the best ways to obtain long-fibered wood of cottonwood are to:

1. Use the outer wood of old trees such as slabs and edgings from sawlogs;

2. Grow stands to older ages such as 25 to 35 years;

3. Thin young stands to increase the diameter growth of crop trees; and,

4. Select fast growing clones for planting.

Recently we began a clonal test of poplars. We have acquired 65 clones of the northeast hybrids, 4 cottonwood selections from the Tennessee Valley Authority, 3 of the Wisconsin cottonwood selections, 3 of the Iowa natural hybrids, and we have screened one local cottonwood selection. In cooperation with the Main Brothers Box and Lumber Company in Illinois these clones are being used to establish a nursery from which outplantings will be made. For some of the clones we have very few cuttings and it will be at least another year before we can begin field tests. We hope to establish experimental plantations that can be used for future genetic studies, and to test these clones for their suitability in the Central States.

Our future studies will continue along these lines. We will continue to make field tests of promising hardwoods; we will continue to search for superior trees; we will continue to study seed and regeneration problems; and we are now beginning a study of the variability in specific gravity of cottonwood.

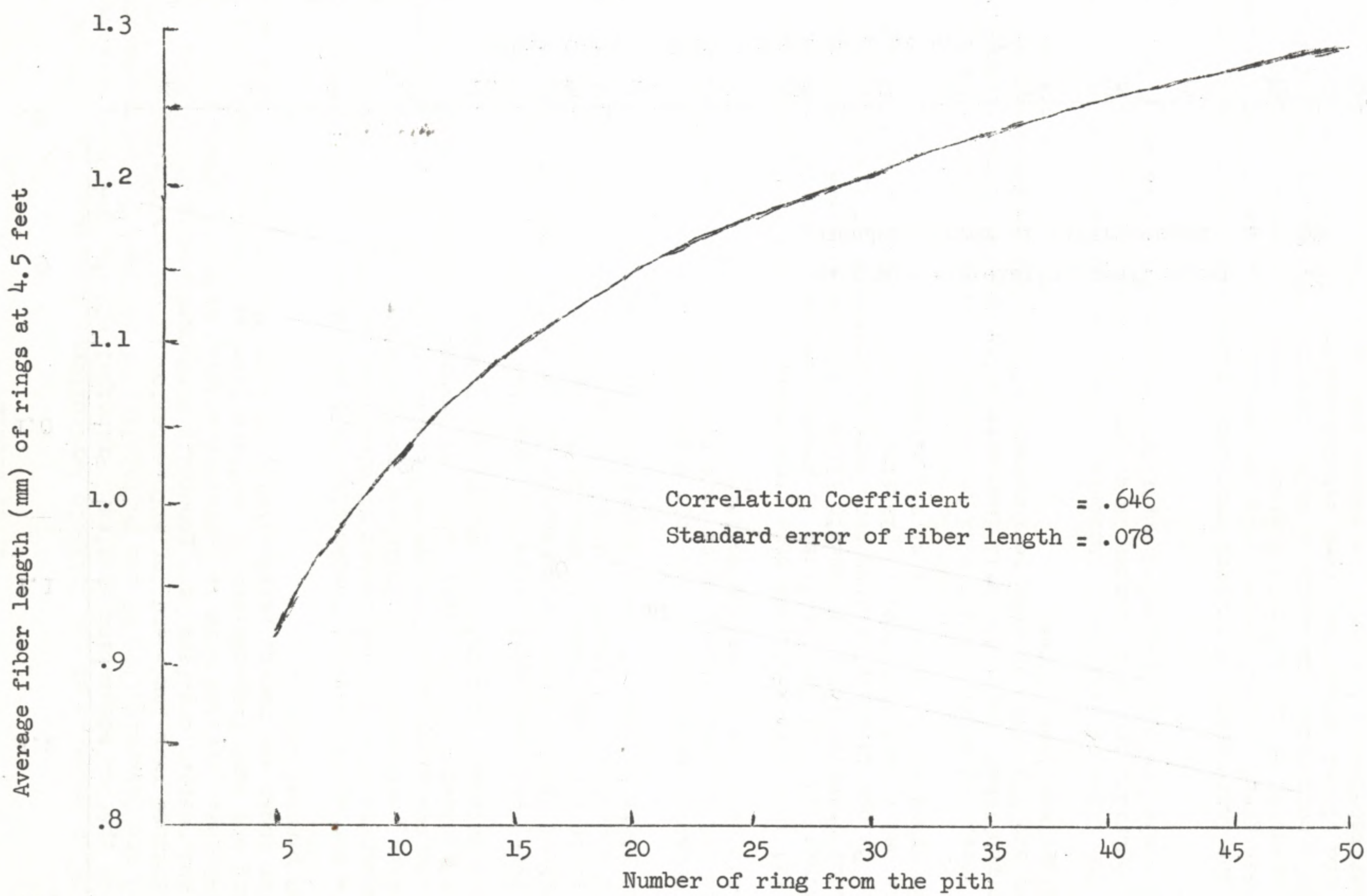

Figure 1. Average fiber length increases with the number of the annual ring from the pith.

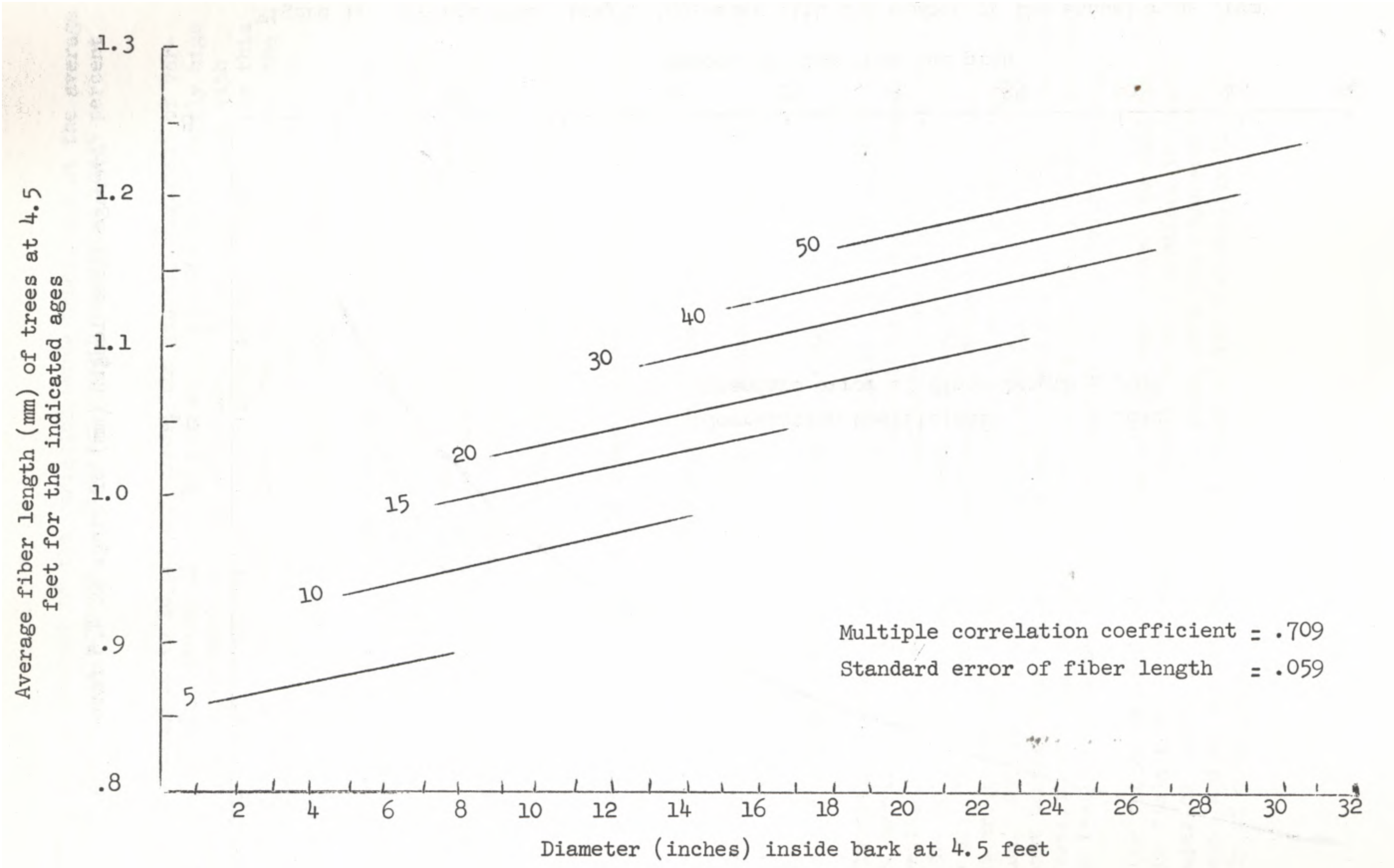

Figure 2. The older the ties and the larger the diameter, the longer the fibers.