Cottonwood Improvement in the Lower Mississippi Valley

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In river bottoms of the lower Mississippi Valley, cottonwood (P. deltoides Bartr.) is a pioneer species of major economic importance. Because of its extremely rapid growth on suitable sites, it has considerable potential for intensive management in plantations. Poplar culture in the South may eventually approach agronomy in levels of investment and return. Cottonwood also has the potential for spectacular failure under a wide range of conditions. With few forest species is it so important that the silviculturist apply all the techniques and knowledge available. To merit costly attention, the material must be genetically worthy. Thus development of genetically superior cottonwood is simply an essential aspect of intensifying its culture.

Cottonwood is used by the lumber, veneer, and paper industries; tree improvement goals must derive from the requirements of all three uses. Briefly, the products of cottonwood breeding should be inherently straight, cylindrical, rapid-growing trees with clear wood having high specific gravity and long fibers. Good form and rapid growth will be partly dependent upon inherent pest resistance.

The object of this paper is to review the status of cottonwood improvement research in the lower Mississippi Valley. Specifically, I will discuss silvical characteristics strongly related to development and use of improved stock, patterns of natural variation,

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and the nature of breeding systems currently in use. My comments will deal largely with research centered at the Southern Hardwoods Laboratory of the Southern Forest Experiment Station. Active cottonwood improvement programs are presently limited to those of this laboratory and the Texas Forest Service.

SILVICAL CHARACTERISTICS RELATED TO IMPROVEMENT

Cottonwood is a dioecious species with prolific annual seed crops. Flowerbuds are formed in early summer; flowering and wind pollination take place the following spring, and seed dispersal occurs between May and August in the lower Mississippi Valley. Seeds germinate and become established on moist soil immediately after dispersal. Unlike some other *Populus* species, cottonwood can be easily grown from seed in the nursery.

Controlled crosses essential to breeding can be made on bottle-grafted scions bearing female flowers. These grafts to juvenile stock may be made under greenhouse conditions in early fall or immediately prior to forced flowering in late winter. Fresh pollen is easily obtained in late winter by forcing male flowers. One or two catkins containing several hundred seeds apiece are subsequently matured on each graft in two to three months. In short, cottonwood's reproductive characteristics lend themselves to genetic improvement research.

Populus deltoides is easily propagated by stem cuttings. Twenty-inch-long unrooted cuttings of juvenile material are predominantly used as planting stock. Products of genetic improvement research will undoubtedly be clones vegetatively propagated on a commercial scale.

Intensive cultural practices including thorough site preparation and weed control are now recommended in establishing cottonwood plantations. Irrigation and pruning may become common. Breeding programs must incorporate tests of the relationship between cultural practice and expression of genetic potential.

Site relationships are currently of major interest to cottonwood growers and improvers. River-channel deepening and straightening are reducing occurrence of natural cottonwood on new riverfront sites, and hence necessitating planting or seeding on older land. In some cases planting is being attempted, for pressing economic reasons, on soils whose nutritional or textural characteristics are marginal for cottonwood. Success on such sites may require especially adapted stock.

NATURAL VARIATION

While silvical considerations affect the nature of cottonwood breeding, improvement is fundamentally dependent upon natural variation and inheritance of characters to be modified. The literature on natural variation in European and North American. *Populus* species is extensive, and there are a few data on inheritance; but the cottonwood population in the lower Mississippi Valley has received little investigative attention. Consequently, the first job of the Southern Hardwoods Laboratory has been to obtain data directly applicable to breeding in this area. This is being done through (1) direct sampling in natural stands, (2) clonal tests of randomly selected trees, and (3) progeny tests. I shall summarize some initial results.

In natural stands at several locations in the Mississippi Delta, specific gravity of wood samples from individual trees ranged from .32 to .46, and 98 percent of this variation was due to differences between trees within stands. Wide variation in dates of flowering and seed dispersal followed the same pattern as wood density; within-stand variation was much greater than that between stands or between locations. Further, dates of phenological events for individual trees in different years were significantly correlated; this indicates, for example, that within a given group of trees flowering occurs in the same sequence year after year.

Through clonal 'tests of random selections on several sites, we can determine the degree to which clones (genotypes) vary, and can evaluate the relative effects of genetics and environment. Variation in juvenile growth rate of clones is, as one would expect, strongly influenced by environment, but our data indicate that it is sufficient to provide around a 9-percent increase in early height growth if one selects the best 10 percent of an average population on the basis of test results. Form of juvenile cottonwood varies widely and is under moderate genetic control. Some clones have numerous small branches and a Christmas-tree-like shape; others are rangy, loose-limbed trees. The typical form is candelabra-like.

Clonal variations in bark color and morphology, under strong genetic control, are also strikingly evident in juvenile populations.

Phenological variation in clonal tests is as broad as that observed in natural stands, and has considerable genetic basis. An inherently early foliating clone can be developed simply by taking cuttings from the first flushers in a natural stand.

The most spectacular clonal differences observed to date are in relative resistance to Melampsora rust, a leaf rust that infects trees during August and September and may cause early defoliation. We have found a few clones that are almost completely resistant to this pathogen, even during heavy general infestations. Inheritance data indicate that a 100-percent improvement in juvenile rust-resistance can be made in one generation through intensive selection.

While field sampling and clonal tests may delineate natural variation in a population and determine the degree of genetic control over this variation, only progeny tests tell how genetic control is passed from one generation to another. To date, in one-parent (open-pollinated) progeny tests we have observed significant familial differences in juvenile growth, wood properties, phenology, and disease resistance. In one such test a strong positive genetic correlation was found between growth rate and fiber length, indicating that selection for one of these characters will result in a concomitant increase in the other. Perhaps the most significant feature of these tests, however, is the great diversity found within half-sib families. While this is not especially unusual, it indicates a good possibility for improvement through individual-tree selection in these families. We are now designing two-parent (control-pollinated) progeny tests that will yield more refined inheritance information.

Data from juvenile tests and field sampling give at best a limited conception of the population, one that may change with later results. However, we feel that a general picture is emerging. First, the population in the lower Mississippi Valley appears to be very heterogeneous. Second, most of this variation is accounted for by tree-to-tree differences within stands. Third, some characters with especially wide variation (i.e. phenology and morphology) appear to be under strict and perhaps simple genetic control.

In view of these tentative conclusions some ecological considerations are, I think, important. The Mississippi River has been influential in at least two ways. First, it brings a continuous supply of new germ plasm into the population. A whole tree may be carried on the spring flood from Cairo to lodge and disperse pollen at Natchez. Second, annual floods of varying scope and duration coupled with cottonwood's seed dispersal characteristics have probably kept the genetic pot pretty well stirred. The end result may be a population of unusual and continuing genetic diversity with geographical differentiation (if such exists) occurring between river basins. A major racial study now under way at the University of Illinois should test this hypothesis.

BREEDING SYSTEMS

Since cottonwood is propagated by cuttings, improvement once expressed in a single genotype can be maintained indefinitely on a commercial scale. Thus early improvement gains may be rapidly secured by selecting the better genotypes from a natural population and directly propagating them. A simple improvement program consists of selecting the best juvenile phenotypes in a natural population, testing them as clones, then selecting the genetically best clones for commercial use. This procedure is currently being used by the Texas Forest Service and a few industries. Improvement of characters which vary widely and have strong genetic control may be great. The technique guarantees some gain if enough clones are properly tested and is certainly a logical initial step toward improvement; but it has important deficiencies as a major long-term improvement system. One fault is that improvement is necessarily limited to the best genotypes in a natural population. Furthermore, an inordinate amount of time may be needed to find these genotypes.

The Southern Hardwoods Laboratory's program is essentially an extension of the above system. It includes progeny evaluation as well as field selection and clonal tests. Initial selections are made in mature stands and are based on growth, form, apparent pest resistance, and wood properties. Potential select trees are judged in relation to neighboring dominant and co-dominant "check" trees.

Field selections are vegetatively propagated and stored in replicated clonal tests.

Open-pollinated seed has also been collected from female selections and used to establish nursery progeny tests. Juvenile selections are then made from these progeny plantings. Commonly, the better trees in the better families are selected after 2 years' growth. Selection for growth rate includes at least the top 1 percent of the population; selection for characters less affected by environment may be more intensive.

These juvenile selections are then subjected to two clonal tests. The first is preliminary. It includes 100 clones and is run for 1 to 2 years on two alluvial sites representing extremes for cottonwood--Sharkey clay and Commerce silt loam. Approximately 60 percent of these clones are rogued. Clone-site interactions may be of major importance in selection for early growth. Some clones that perform well on the good site fall in the lower half of the test population on tie poor one; others that are among the top 25 percent on Sharkey clay sometimes are relatively poor performers on Commerce loam.

Selected clones are placed in long-term tests that are more extensively replicated than preliminary tests. At least two sites are used, and clonal plots are large enough to allow two thinnings. A group of randomly selected clones is used as a control. The best clones in the long-term tests will be some of the program's final products.

The system still only sifts out the best genotypes in the natural population. Further manipulation will be required to produce uniquely superior stock comparable to products of crop breeding. The exact nature of this manipulation is unknown at present, but a modified form of "recurrent selection" is likely to be used. In such a system, parents evaluated in clonal and progeny tests are intercrossed to produce progeny from which individuals with favorable attributes of both parents are selected. Recurrent cycles of selection and intercrossing gradually accumulate favorable genes as undesirable individuals are eliminated. At any stage of the process, progeny from proven desirable crosses may be either mass-produced as improved seedling stock or selected, tested, and used commercially as clones.

SUMMARY

Cottonwood improvement in the lower Mississippi Valley, now in its initial stage, is an essential part of research leading to intensification of poplar culture in the region. The new trees should have superior genetic potential for growth, form, wood properties, and pest resistance. The nature of our current genetic improvement programs is strongly influenced by cottonwood's silvical characteristics, some of which are distinctly advantageous to effective breeding. Site relationships are of particular importance both in producing and utilizing genetically superior stock.

Natural variation of characters potentially important to improvement appears to be broad in the lower Mississippi Valley cottonwood population. Patterns of variation may be strongly influenced by rapid movement of germ plasm from more northern ecotypes into the population via river systems. Productive breeding systems utilizing this variation may range from simple mass selection and subsequent clonal testing to long-range programs of recurrent selection.