PHENOTYPIC AND GENOTYPIC VARIATION IN EASTERN COTTONWOOD IN THE SOUTHERN GREAT PLAINS

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The demand for wood cellulose is ever-increasing and is expected to more than double the present usage before the end of this century. Where will the wood be produced considering competition for land by urban sprawl, lakes, highways, recreational areas, and agricultural crops? One possibilit would be the utilization of land suitable for cottonwood (*Populus deltoides* Bartr.) production which exists along streams and on sub-irrigated soils throughout the Great Plains region.

This paper reports, in general terms, variation in cottonwood along a portion of the western edge of the species range. The pattern of natural variation in specific gravity, fiber length, and diameter growth rate is presented first, followed by variation observed in fiber length, specific gravity, fiber diameter, microfibril angle, gelatinous fibers, lean, diameter growth, height growth, limbs/foot, and sprouting ability for 200 plus clones grown at one location.

METHODS

Plot and Environmental Description

Twenty-four plots were established, each approximately 60 miles apart, along the Red, South Canadian, and Cimarron Rivers from the Oklahoma-Arkans state line westward, about 600 miles, to the headwaters. In addition, for comparative purposes, a single plot was sampled on the Mississippi River : of Dewey, Arkansas.

The plot locations, except for the Mississippi plot, are characterized by the following environmental conditions:

a. Average annual rainfall for the five-year period during which the wood evaluated was formed ranged from 48.8" in the southeast to 13.8" **in** the northwest.
b. Elevation from 310 feet in the southeast to 6500 feet in the northwest.
c. Average number of frost-free days from 240 in the southeast to 175 in the northwest.
d. Minimum temperature for January from 3°F. in the southeast to -28°1 in the northwest.
e. Maximum temperature for August from 120°F. in the southwest to 102° in the northwest.

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Field Sampling

At each plot two 12-millimeter increment cores were extracted from the bark to the pith on opposite sides of each of ten dominant trees. Twenty cuttings were taken from the most vigorous portion of the crown of each sample tree.

Age of tree at breast height was determined by ring count. Annual rings for a five year period (Years 3-7) were cut from the core and measured for an estimate of radial growth rate. Specific gravity was then determined for each five-year core, utilizing the maximum moisture content method, as outlined by Smith (1954). The sixth and seventh annual rings **were** cut from the core and macerated using the procedure described by Franklin (1945). The length of twenty whole fibers were measured for each sample.

Field Planting

The twenty cuttings from each sample tree were planted near Norman, Oklahoma during April 1967. The planting design was a split-plot with four replications. Each replication contained a five ramet row plot for each of the ten clones from the 25 geographic sources grouped by clones within sources. Spacing between rows was 24 inches and within rows was 18 inches.

After the end of the first growing season, height, diameter at 20 inches above the ground, and number of limbs per foot were determined for all clones. Stem cross sections were also taken at 20 inches above ground from all clones for specific gravity determinations.

For an intensive wood study, samples were taken from four ramets from each of forty-three clones representing seven geographic sources along the Red River. Fiber lengths, fiber diameters, microfibril angle, percent gelatinous fibers, and degree of lean were measured for each ramet.

All of the one year old trees produced from cuttings were harvested and used in field plantings. The one year old stumps were allowed to sprout for production of additional cuttings. In August 1968 the number of sprouts per stump were counted to determine geographic variation in sprouting.

This paper is intended to be general and cover a wide range of variables. For this reason, much of the information presented is based on geographic source averages. Detailed information about procedures and results will appear in other publications.

RESULTS

Specific Gravity

Specific gravity of the wood from natural stands, based on plot means, ranged from 0.36 for a plot in New Mexico on the Cimarron River to 0.45 for a plot in south central Oklahoma on the Red River. The trees with lowest specific gravity from six sources on the Canadian River had higher specific gravity than the high specific gravity trees from the Mississippi source (0.35). **On an** individual tree basis, specific gravity ranged from 0.30 to 0.50. The mean for all sources combined, except the Mississippi source, was 0.404.

In general, specific gravity of the wood along all three rivers was lowest in the east and increased toward the west. The linear correlation coefficient between specific gravity and longitude was 0.47, significant at the 0.0[5] level of confidence. Specific gravity by rivers,was lowest for the Red (0.39) and highest for the Canadian (0.42).

When all clones were grown at one location, then compared for specific gravity, the same relative geographic source pattern as stated for natural stands wes observed. Specific gravity, based on geographic source means, ranged from 0.35 to 0.41. Based on clone means specific gravity ranged from 0.30 to 0.47. Specific gravity increased from 0.35 for sources in eastern Oklahoma to 0.40 for sources in western Oklahoma. Clones from the Texas and Oklahoma Panhandles, New Mexico, and Colorado tended to have lower specific gravity than clones from western Oklahoma. This decrease in specific gravity for clones from the extreme western portion of the range was probably a result of low vigor exhibited by clones that had been moved hundreds of miles from their native habitat. Clones from the Red River had average specific gravity of 0.37, whereas, clones from the Canadian and Cimarron Rivers averaged 0.38.

Fiber Length

The length of fibers, based on plot means, ranged from 0.94mm to 1.28mm. Fiber length based on tree means ranged from 0.88mm. to 1.42=4 The mean for all sources was 1.07mm. Fiber length of trees along the Red River exhibited a linear east-west trend with fiber length decreasing from 1.28mm. in eastern Oklahoma to 0.98 in the Texas Panhandle. A decrease in fiber length from east to west was not evident for the Canadian and Cimarron Rivers. The mean fiber length for the Mississippi River source (1.06mm.) was about the same as the overall mean for the Red, Canadian, and Cimarron Rivers (1.07mm.).

The length of fibers of clones grown at one location ranged from 0.61mm. to 0.85mm. Variation in fiber length, based on geographic source means, ranged from 0.67 to 0.81. In considering fiber length from the Red River only, the linear correlation coefficient between longitude and fiber length is -0.85 significant at the 0.05 level of confidence.

Diameter and Height Growth Rate

Diameter growth rate stated here for natural stands is based on the amount of increase in diameter inside bark for years 3 through 7 from the pith. Based on geographic source means, diameter growth ranged from 7.0 inches in five years for a source on the Red River in southeastern Oklahoma to 1.7 inches in five years for the source representing the extreme western edge of the range on the Canadian River. Diameter growth for a five year period based on individual trees ranged from 11.0 inches to 0.8 inches.

Differences in diameter growth of trees between rivers were quite large, being significant at the 0.025 level of confidence. Trees on the Red River grew 70 percent faster than trees on the Canadian and 25 percent faster than trees on the Cimarron.

Along all three rivers there was a definite decrease in rate of diameter growth from east to west ($r = -0.65$).

When all clones were grown at one location the same east-west trend in diameter growth rate occurred. Clones from eastern Oklahoma tend to grow faster in diameter than clones from the extreme western edge of the species range.

Based on geographic source means, diameter growth ranged from 0.56 to 0.94 inches after one growing season. Diameter growth rate based on clone means ranged from 0.2 to 2.0 inches.

Height growth exhibited the same east-west pattern as stated for diameter growth. Trees from the extreme western edge of the range tend to grow as fast as trees from eastern Oklahoma until about mid-summer when height growth of trees of western origin tends to decline or for some clones ceases.

Based on geographic source means there is a 30 percent difference in height growth between the best source and the poorest source. Based on clone averages the best clone is 110 percent superior in height growth as compared to the poorest clone.

Fiber Width and Microfibril Angle

Width of fibers and the orientation of microfibrils in the cell wall varied very little between geographic sources. Fiber width based on source means ranged from 19u to 20u. Differences based on clone means ranged from 17u to 21u.

Microfibril angle, based on geographic source means, ranged from 20.1 to 22.0 degrees. Based on clone means microfibril angle ranged from 17.2 to 26.9 degrees. A geographic pattern for fiber width and microfibril angle variation was not evident.

Gelatinous Fibers

The percentage of gelatinous fibers present in the sample cross-section increased from east to west. Gelatinous fibers, based on geographic source means, ranged from 21.3 to 30.1 percent and based on clone means, ranged from 14.5 to 39.3 percent. The increase in amount of gelatinous fibers from east to west is due, in part, to an increase in amount of tree lean from east to west.

Limbiness of Trees

One of the most striking differences between clones and between geographic sources is the variation in number of limbs. On the Red River the number of limbs per foot, based on source means, ranged from 1.5 **in** the east to 4.1 in the west. Based on clone means, the number of limbs per foot ranged from 0.6 to 5.7. It is not known at this time the exact influence of these limbs on wood quality. All limbs may not persist for a long period of time; but if the strong geographic pattern remains, wood quality would certainly be affected.

Number of Sprouts per Stump

From the standpoint of cutting production in the nursery or cellulose production on short rotations, the sprouting habit of different clones and geographic sources is very important. Sprouting habit followed the same geographic pattern as stated for number of limbs. Based on geographic source means the number of sprouts per stump ranged from 4.6 to 8.7.

Drought Resistance

Drought resistance as used here means that a clone has the capacity to survive in the following environment:

a. Elevation	2300 feet
b. Annual rainfall	23 inches
c. Soil	Sand dune greater than 48" in depth
d. Site	Subject to high velocity, hot, dry winds during growing season

Sixty-nine clones, each represented by twenty, 20-inch cuttings, were tested. At the end of the first growing season over 50 per cent of the clones had zero survival. One clone had 100 per cent survival. Clones originating in western Oklahoma tended to survive better than clones from eastern Oklahoma although several promising clones from eastern Oklahoma were observed.

CONCLUSIONS

This study has shown wide variations between geographic sources and between trees in stands for many economically important traits. These geographic differences parallel environmental gradients. The environmental differences, through natural selection, have caused genetic variation to occur between different geographic localities.

Genetic variation between geographic sources is of sufficient magnitude for growth rate, fiber length, tree lean, gelatinous fibers, number of limbs per foot, sprouts per stump, drought resistance, and specific gravity, that geographic origin must be considered in a cottonwood selection and breeding program.

Trees from eastern Oklahoma tend to have longer fibers, lower specific gravity, faster growth rate, straighter stems, fewer gelatinous fibers, fewer limbs, fewer sprouts per stump, and be more susceptible to drought than trees from western Oklahoma. Western Oklahoma cottonwood can be used to increase specific gravity and drought resistance of trees grown in the eastern part of the state and trees from the eastern part of the state can be bred with western Oklahoma trees to increase growth rate and wood quality of trees to be grown in western Oklahoma.

LITERATURE CITED

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