Comparison of First-year Wood Fibers among different Poplar Clones

by

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The uses of poplar or cottonwood (Populus L.) are more or less related to the quality of its fibers (Markwardt, 1930; Ritter, 1935; Esau, 1960). The quality of the fibers (length and strength) is dependent upon many factors. Factors such as heredity, soil depth, soil fertility, and other environmental factors are all important (Swan, 1958; Liese and Dadswell, 1959; Boyce and Kaeiser, 1961). A slight change in one of these factors can cause reduction in fiber length. It is, therefore, desirable to obtain clones that have superior genetic constitutions and are least affected by the environment.

A considerable amount of work has been done regarding factors governing variations in fiber length. In addition to the work done on fiber length in relation to the lean of trunk and position of fibers in the trunk of eastern cottonwood (P. deltoides Bartr.) (Kaeiser and Stewart, 1955), work has also been done on tension wood, gelatinous fibers, variation in the length of fibers in relation to the growth rate, and variation in fiber length in relation to the genetic constitution of the clones (Boyce and Kaeiser, 1961). Kaeiser's work (1956) with eastern cottonwood shows that variation in fiber length indicates at least some effects of growth-factors on the morphology of the wood. The average fiber length in her samples increased with ring number out from the pith. A trend towards greater fiber length was shown in trees that had greater lean. The work done by Kaeiser and Stewart (1955) showed that tree age and amount of lean were independent in their influences on fiber length, and also that the range of fiber lengths increased with increasing trunk diameter. However, no attempt was made to assess possible effects of genetic factors on either the variations in fiber length or the occurrence of concentrations of gelatinous fibers.

Bissett and Dadswell (1949) worked on the variation of fiber length within one tree of Eucalyptus regnans F. Mueller. They also found that the fiber length increased with increasing distance from the pith. Kennedy (1957) found that fast growing shoots had longer fibers than slow growing ones. Liese and Ammar (1958) found that the length of fibers and growth rate were inversely proportional within any one ring of poplar. Spurr and Matti (1954) had results from their study which also agreed with the previously mentioned works: the length of the fibers increased with an increase in their distance from the pith. Liese and Dadswell (1959) found that fiber length was greater on the shady side of the stem than the sunny side. Kennedy and Smith (1959) studied the effects of site, growth rate, and ,heredity on the fiber length and specific gravity of black cottonwood (P. trichocarpa Torr. et Gray) and the hybrid "regenerata" poplar. They also found that the fiber length increased with increase in growth rate of one-year-old plants.

So far as the writer has been able to ascertain from a search of the literature, no comparative studies of fiber length in one-year-old wood have been reported among different clones of poplar.

OBJECTIVES

The objectives of this study were:

1. To determine the amount of variation in the wood fiber lengths among seventy-two one-year-old poplar clones that were grown in a similar environment;

2. To look for the relationship between fiber length and diameter of the stem inside the bark;

3. To look for the relationship between fiber lengths of genetically related clones; and

4. To identify those clones that inherently have the longest fibers and those that inherently have the shortest fibers.

EXPERIMENTAL METHOD

The research material was collected from an experimental nursery, maintained at Main Brothers Box and Lumber Company, Karnak, Illinois, in cooperation with the Central States Forest Experimental Station of the U.S. Forest Service. The nursery contained poplar clones that were all planted in February and were one year old when investigated. Seventy-two of the seventy-eight clones of known pedigree were selected for stem sampling (Table 1). A Columbia University publication (Anonymous, 1958) was used to check cultivar names and for general taxonomic treatment of species within the genus.

Only straight portions of the stem were selected. Three stem samples of approximately four to five inches in length and about one foot from the ground surface were taken from each clone. One of the three samples was from the stem of largest diameter and the other two were from the smallest diameter stems. The specimens were labeled and stored in air tight plastic bags. They were stored at approximately fifteen degrees centigrade until they were used for further examination.

The amount of wood macerated for each specimen was approximately 1500 cu. mm, being limited by the amount of stem that could be sampled. To determine the volume, the diameter of the stem without the bark and the diameter of the pith were measured. By subtracting. the diameter of the pith from that for the entire stem inside the bark, the diameter and the radius of the wood portion could be calculated. To decide the height of the wood core to use in order to obtain a desired volume, the following formula was used:

$$H = \frac{V}{(3.14)(r^2)}$$

where H represents the height, r the radius, and V the volume of the core.

After removal of the bark and pith the wood was sectioned along the grain in match stick sized pieces and put into a one-inch-wide and eight-inch-long test tube.

Approximately ten volumes of Jeffery's solution (Johansen, 1940 per volume of wood were added and the test tube was then tightly stoppered with a cork. The specimens generally took about 24 hours to become macerated. The wood was then shaken vigorously in the test tube in order to complete the separation of all of the cells. Repeated washing with distilled water was done at this time to remove the maceration fluid; this was done by allowing the fibers to settle and decanting the water. Washing was continued until the solution did not turn blue litmus paper red. After the last decanting of the water, the wood was stored in seventy percent ethyl alcohol. Five drops of a ten percent solution of Safranin 0 in fifty percent ethyl alcohol was added to each test tube in order to stain the lignified walls of the fiber cells.

Before taking a fiber sample, the stoppered test tube was shaken vigorously to suspend the cells. While still in the suspended state, approximately five cu. mm of sample was removed by using a pipette with a five-mm-diameter bore. Previous sampling proved that one sample was sufficient to complete the measurements of the first hundred whole fibers (Tippo, 1941; Kaeiser, 1956). The examination of the macerated wood was done with a TRI-SIMPLEX Bauschand Lomb micro-projector at a magnification of forty-nine. This magnification proved adequate to detect all kinds of cells and in distinguishing broken fibers from the entire ones. The projected lengths of fibers were marked on onion skin paper and measured. From the total length of fibers the mean length was calculated for each specimen, as well as the range.

Further analysis of the data was performed by the Data Processing and Computing Center of Southern Illinois University. The data processed for each specimen included stem diameter inside the bark, pith diameter, average length of fibers, and the maximum and minimum lengths of fibers. A regression analysis was used to determine the relationship between fiber length and stem diameter inside the bark, and between fiber length and pith diameter.

RESULTS

The results of this study can be summarized by five paragraphs:

1. Fiber length varied among clones. The longest mean fiber length and the shortest mean fiber length were 0.76 mm and 0.47 mm, respectively. The range for the average fiber lengths was 0.29 mm. The computed mean fiber length was 0.60* 0.04 mm.

2. All of the data for the fiber lengths showed that lengths increase with increase in the diameter of stem inside the bark (Figure 1).

3. The regression analysis between the pith diameter alone and fiber length did not show any relationship.

4. The data showed that there was no close relationship between the fiber length and the genetically related clones.

5. Some clones proved either superior or inferior in genetic constitution for fiber length. Table 2 shows six clones with outstandingly longer fiber lengths and eight clones with outstandingly shorter fiber lengths. To reduce the possibility of error in the results, the fourteen outstanding clones were resampled. The second measurements corrobrated the validity of the first results.

DISCUSSION

Of the seventy-two clones, the average fiber lengths varied from 0.47 to 0.76 mm, the computed mean fiber length being 0.60 ± 0.04 mm. The correlation coefficient (r) for the length of fibers and the stem diameter inside the bark was 0.81. Therefore, r^2 0.66. This is interpreted to mean that the stem diameter inside the bark accounted for about 66 percent of the variation in the fiber lengths. The total variation in the fiber length was 0.29 mm. The diameter of the stem inside the bark accounted for 0.66 x 0.29 mm 0.19 mm of the variation in the fiber lengths. This leaves 0.10 mm of variation to be accounted for by miscellaneous genetic differences, errors of measurement, and unknown environmental effects. As mentioned previously, factors such as soil and environmental conditions were most similar. Therefore the environmental effects unaccounted for by stem diameter are probably very small. This suggests that the genetic variation is probably less then 0.10 mm.

It is known from the literature (Bissett, Dadswell and Amos, 1949; Bissett and Dadswell, 1950; Pillow, 1952; Spurr and Matti, 1954; Kaeiser, 1956; Liese and Ammar, 1958; Boyce and Kaeiser, 1961) that there is a relationship between fiber length and stem diameter. The fiber length has in this study also been proved to increase with an increase in the stem diameter (Figure 1).

A similar study made with mature eastern cottonwood trees by Boyce and Kaeiser (1961) also showed a wide range in fiber lengths. Fiber length varied with age of tree, the mean fiber lengths for eighty-seven trees at 4.5 feet above ground level varying from 0.85 to 1.28 mm. Age and stem diameter accounted for about 50 percent of the variation. The standard error of estimate was 0.06. This study showed that the fiber lengths in the fifth ring were related to fiber lengths of later rings. The findings in the present study for one-year-old stems thus agree well with the previous studies using older trees.

Table 3 shows the clones which were either outstandingly superior or outstandingly inferior in their genetic constitutions with respect to fiber length. Deviations from the expected are given in numbers of standard errors.

The results of this study can be used to select the longest- and shortest-fibered clones from the seventy-two clones tested. Breeding followed by repeated selection of the progeny from the superior clones could possibly yield clones with longer fibers than the longest-fibered clones found in this study. Individuals that deviated from the average fiber: length by 1.5 standard deviations are considered to be superior clones for future breeding.

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SUMMARY

A study was performed on seventy-two clones of Populus L. Wood samples were taken from one-year-old stems that were growing in the same nursery. These clones consisted of selections of Populus deltoides Bartr. and various hybrids between the following: P. deltoides, P. trichocarpa Torr. et Gray, P. charkoviensis Schroed.,

P. nigra L., P. sargentii Dode,P. maximowiczii Henry, P. grandidentata Michx., P. alba L., P. laurifolia Ledeb., and P. simonii Carr.

Mean length of fibers for the seventy-two clones varied from 0.47 to 0.76 mm; the range was 0.29 mm. The average fiber length for all the clones was about 0.60 mm.

Stem diameter inside the bark accounted for 66 percent of the total variation in fiber length.

The results of this study showed six clones outstandingly superior and eight clones outstandingly inferior in their fiber lengths.

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Table 1.--The following table shows the designation number, the clone number and the parentage of the clones.

Parentage of the clones	Clone Number	Clone designation Number
P. deltoides	Ky. 4	49
"	Ky. 8	50
"	Ala. 11	51
"	Ala. 12	52
"	CR. 1	12
"	Wisc 5	53
"	Wisc 87	54
"	Wisc 97	55
P. deltoides x P. trichocarpa	NE 202	37
"	NE 205	38
"	NE 206	39
"	NE 207	40
"	NE 212	41
"	NE 215	42
"	NE 216	43
"	NE 346	44
"	NE 350	45
P. deltoides x P. charkowiensis	NE 318	22
P. deltoides x P. nigra caudina	NE 221	24
"	NE 222	25
"	NE 224	26
"	NE 225	27
"	NE 228	28
"	NE 353	29
"	NE 355	30
"	NE 358	31
"	NE 359	32
"	NE 360	33
"	NE 366	34
P. deltoides x P. nigra plantierensis	NE 241	35
"	NE 242	36
P. deltoides x P. nigra volga	NE 236	46
"	NE 237	47
"	NE 238	48
P. deltoides angulata x P. deltoides	NE 244	1
"	NE 245	2
"	NE 246	3
P. deltoides angulata x P. trichocarpa	NE 249	4
"	NE 251	5
"	NE 252	6
"	NE 253	7
"	NE 254	8
"	NE 255	9
"	NE 374	10
P. berolinensis x P. candicans	NE 327	15
P. berolinenesis x P. maximowczii	NE 46	56
"	NE 50	57
P. charkowiensis x P. nigra caudina	NE 17	16
"	NE 20	17
"	NE 21	18
"	NE 378	19
"	NE 313	20
"	NE 314	21
P. charkowiensis x P. canadensis robusta	NE 316	23
P. maximowiczii x P. nigra caudina	NE 53	58
P. maximowiczii x P. nigra plantierensis	NE 51	59
"	NE 52	60
P. maximowiczii x P. trichocarpa	NE 41	61
"	NE 388	62
P. nigra x P. canadensis eugenei	NE 278	63
P. nigra x P. laurifolia	NE 5	64
"	NE 284	65
P. nigra x P. trichocarpa	NE 9	66
"	NE 285	67
P. sargentii x P. berolinesis	NE 36	69
"	NE 37	70
P. sargentii x P. nigra italica	NE 273	71
P. sargentii x P. simonii	NE 274	72
P. grandidentata x P. alba	Sherrill Crandon	11
P. rasumowskyana x P. nigra plantierensis	NE 341	68
P. trichocarpa x P. nigra betulifolia	NE 300	14

Table 2.--The following table shows the clones with the longest fibers and the clones with the shortest fibers, and the magnitude of their differences in fiber lengths from the normal range

Designation Number	Average stem diameter mm	Average fiber length mm (a)	Average Pred. fiber length mm (b)	Differences between a and b mm
		Trees with the longest fibers		
2	11.5	0.64	0.59	+0.05
11	15.5	0.69	0.62	+0.07
27	12.5	0.68	0.59	+0.09
49	17.5	0.72	0.64	+0.08
53	18.0	0.69	0.64	+0.05
54	17.0	0.69	0.63	+0.06
		Trees with the shortest fibers		
15	10.0	0.53	0.58	-0.05
23	11.5	0.53	0.59	-0.06
29	12.5	0.55	0.59	-0.04
39	13.5	0.55	0.60	-0.05
40	15.5	0.57	0.62	-0.05
42	13.0	0.52	0.60	-0.08
58	12.5	0.55	0.59	-0.04
69	13.5	0.56	0.60	-0.04

Table 3.--The following table shows the parentage of the clones with the longest and the shortest fibers and their deviations from the expected in standard errors

Design. Number	Clone Number	Parentage of the clones	Deviations from expected in Stand. errors
		Trees with the longest fibers	
27	NE 225	P. deltoides X P. nigra caudina	+2.25
49	Ky 4	P. deltoides	+2.00
11	Sherrill	P. grandidentata X P. alba	+1.75
54	Wisc 87	P. deltoides	+1.50
2	NE 245	P. deltoides angulata X P. deltoides	+1.25
53	Wisc 5	P. deltoides	+1.25
		Trees with the shortest fibers	
60	NE 36	P. sargentii X P. berolinensis	-1.00
29	NE 353	P. deltoides X P. nigra caudina	-1.00
58	NE 53	P. maximowiczii X P. nigra caudina	-1.00
39	NE 206	P. deltoides X P. trichocarpa	-1.25
15	NE 327	P. berolinensis X P. candicans	-1.25
40	NE 207	P. deltoides X P. trichocarpa	-1.25
23	NE 316	P. charkowiensis X P. canadensis robusta	-1.50
42	NE 215	P. deltoides X P. trichocarpa	-2.00

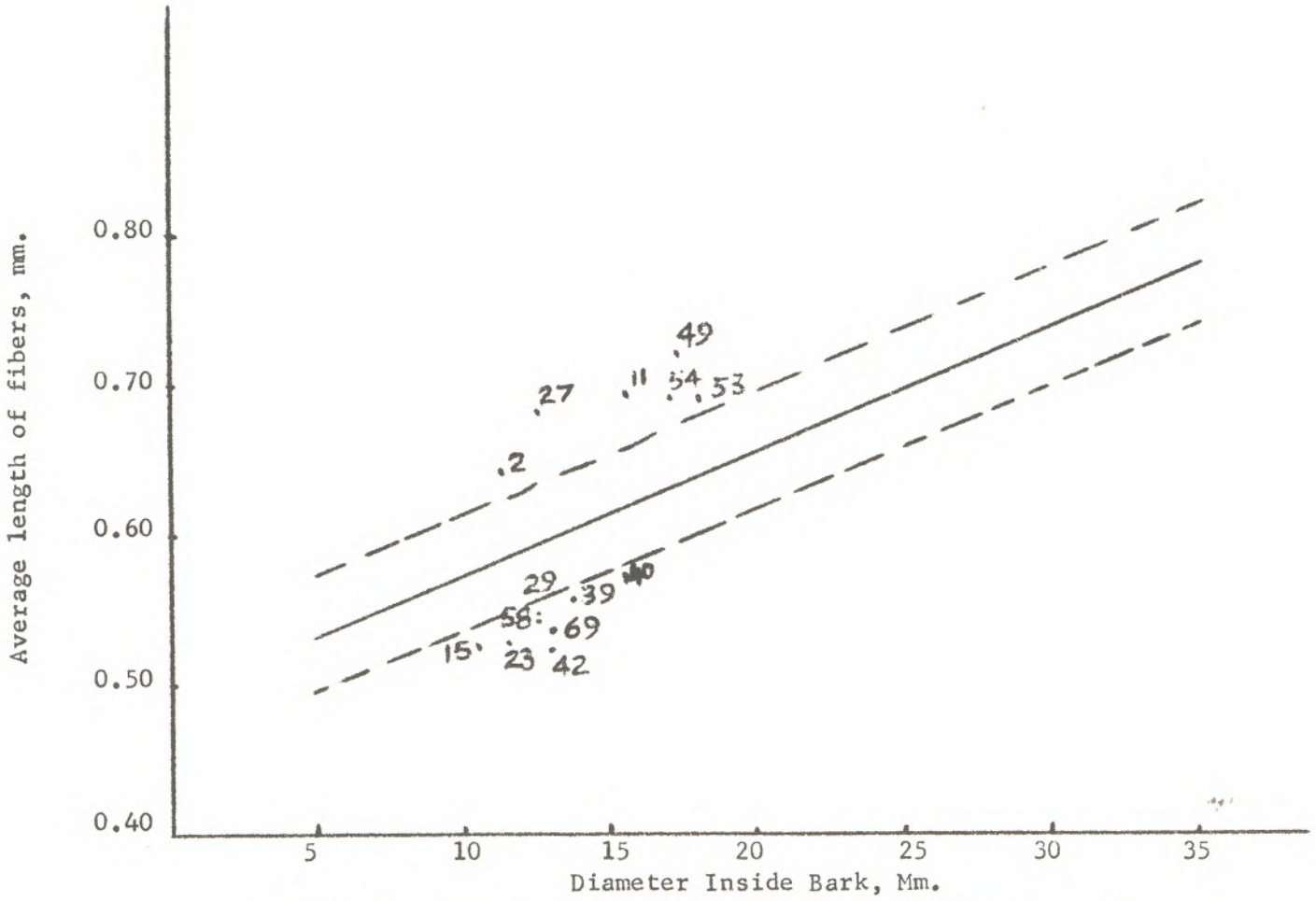

Figure 1.--Average length of fibers as related to the stem diameter inside bark.