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Research Note

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Five Years' Growth of Pruned and Unpruned Cottonwood Planted at 40- by 40-Foot Spacing

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SUMMARY

Four pruning treatments have been applied for 5 years on cottonwood (*Populus deltoides* Bartr.) select clone Stoneville 66, planted at 40- by 40-ft spacing. As pruning severity increased, average diameter and maximum crown width decreased. Diameters ranged from 9.2 inches for trees pruned half of height yearly to 11.4 inches for unpruned trees; crown widths ranged from 16.5 to 24.6 ft.

Additional keywords: *Populus deltoides.*

INTRODUCTION

Cottonwood (*Populus deltoides* Bartr.) grows fast, but its potential maximum diameter increment has not been determined. If wide enough spacing were used at planting on site index 120+, crown development would not be restricted by competition from other cottonwood trees. And resulting diameter growth would serve as an upper limit for comparison to diameter growth at other spacings and would also tell us how fast sawtimber and veneer logs can develop. Widely planted cottonwood trees would need to be pruned for quality growth. A comparison of several pruning intensities would tell us how crown length influences diameter growth. This paper gives data on 5-year growth of widely spaced cottonwoods whose crown length has been controlled by pruning (fig. 1).

METHODS

The 9-acre study area (on Chicago Mill and Lumber Company land at Huntington Point, Bolivar County, Mississippi) was cleared in 1971, fallowed in 1972, and planted in 1973. Because of a 1973 flood, the study was replanted in January 1974. A matrix of 16 rows by 16 columns contained 256 planting spots. Spacing was 40 by 40 ft on Commerce silt loam soil. Three 18-inch cuttings of select Stoneville clone 66 (Land 1974)

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Figure 1.—*General view of cottonwood trees, planted at 40-by-40 ft spacing, leafing out at start of sixth growing season. Tree nearest observer has been pruned to half its height, the next four trees in the row are pruned to a third of their height, and the next group of trees are unpruned.*

were planted at each spot and thinned to one tree per spot the first week of June.

A randomized complete block design was used, with four replications. Each plot per block was 4 rows by 4 columns. Data were analyzed at the 0.05 level of significance (Duncan's Multiple Range Test).

Disking controlled weeds during the five growing seasons.

Pruning treatments were: 1) no pruning (control); 2) pruning the bottom third of the tree yearly (third-height pruning); 3) pruning the bottom half of the tree yearly (half-height pruning); and 4) pruning the bottom 17 ft of the tree (17-ft pruning) when d.b.h. became >8.5 inches, as happened in the 4th year. Trees were pruned in the dormant season: January 1975, February 1976, March 1977, and March 1978. Trees were examined monthly during the growing seasons and any sprouts were removed. But the first examination was delayed until June 1975 because high water made trees inaccessible.

Height and d.b.h. of each tree were measured yearly. Cut limbs of the inside four trees in each pruning treatment plot were counted after the 1st year, and diameters of newly cut limbs were measured at the end of each year thereafter. Maximum crown width of all trees in both a north-south and east-west direction was measured after the 5th year. And, at that time, diameter outside bark at 17 ft of each plot's four inside trees was also measured.

Two replicates of clone 66 had also been planted in January 1974 at 10 by 10 ft in an adjoining study. At the end of the 5th year, the inside 8 trees per 10-tree replicate were measured for d.b.h., height, crown width, diameter outside

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able 1.—*Average height and height growth and d.b.h. and d.b.h. growth by year and pruning treatment*

Treatment	Height					Height growth			
	Year					Year			
	1	2	3	4	5	2	3	4	5
	feet					*feet*			
Check	10.5	23.8	36.9	49.9	62.5	13.2	13.2	12.8	12.6
One-Third	10.8	23.6	36.0	49.9	62.3	12.9	12.4	13.9	12.3
One-half	10.6	23.0	34.8	48.1	59.6	12.4	11.8	13.3	11.6
17-ft[1]	10.9	24.3	36.5	50.0	62.3	13.4	12.2	13.3	12.4
Average	10.7	23.7	36.0	49.5	61.7	13.0	12.4	13.3	12.2

Treatment	D.b.h.					D.b.h. growth			
	Year					Year			
	1	2	3	4	5	2	3	4	5
	inches					*inches*			
Check	1.1	4.0	7.2c[2]	9.6c	11.4d	2.9b	3.2c	2.4b	1.8d
One-Third	1.1	4.1	6.9b	8.9b	10.3b	3.0b	2.8b	2.0a	1.5c
One-half	1.1	3.8	6.3a	8.1a	9.2a	2.7a	2.4a	1.8a	1.1a
17-ft[1]	1.1	4.1	7.3c	9.6c	10.9c	3.0b	3.2c	2.4b	1.3b
Average	1.1	4.0	6.9	9.0	10.4	2.9	2.9	2.2	1.4

[1] Treatment applied after 4th year.

[2] Means appearing with same letter not significantly different within each column at 0.05 level by Duncan's Multiple Range Test.

bark at 17 ft, and length of live crown (Kennedy 1979). Because 10-by-10 spacing is common, these data were compared to 40-by-40 spacing results.

All measured trees were incuded in analyses except four trees replanted the 1st year and trees with broken tops. Where only inside trees were measured and one of these was damaged, an adjacent outside-row tree was measured instead.

RESULTS

Through 5 years no difference between treatments in either total height or height growth occurred in any year (table 1). To the nearest foot, and averaged over all treatments, height mean annual increment (m.a.i.) was 12 ft for the 2d through 5th years. Current annual increment (c.a.i.) was 13 ft in the 2d and 4th years and 12 ft in the 3d and 5th years. Mean height after 5 years was 62 ft.

Differences first occurred in d.b.h. growth during the 2d year (when half-height pruned trees grew less than did trees in other treatments). Total d.b.h. first differed after the 3d year (when unpruned trees were larger than pruned trees). Differences as small as 0.3 inch were significant (table 1). Trees pruned to 17-ft after the 4th year had less d.b.h. growth in the 5th year and smaller total d.b.h. after 5 years than unpruned trees had. Diameters at breast height of all treatments differed after 5 years, when average d.b.h.'s were 9.2 inches (half-height pruning), 10.3 inches (one-third pruning), 10.9 inches (17-ft pruning), and 11.4 inches (unpruned). Diameter at breast height m.a.i. peaked in the 3d year for third- and half-height pruned trees and in both 3d and 4th years for unpruned trees. Current annual increment peaked in the 2d year for pruned trees and 3d year for unpruned trees.

As a measure of form, ratio of diameter at 17 ft to d.b.h. was determined. The ratio was higher for third- and half-height pruning (0.73 and 0.74) than for 17-ft pruning and check (both 0.70). Taper decreased as pruning intensity increased (fig. 2).

Maximum crown width for unpruned trees (24.6 ft) was larger than for pruned trees; crown widths for 17-ft (19.2 ft) and third-height (19.9 ft) pruned

Table 2.—*Average values of pruned limbs by year and pruning treatment*

	Pruned 1/3 ht				Pruned 1/2 ht				Pruned 17 ft
	Year				Year				Year
	1	2	3	4	1	2	3	4	4
No. limbs cut/tree	13.0	13.7	14.5	13.5	17.8	18.4	14.1	19.5	46.2
Limb diameter (in)	*	1.2	1.5	1.5	*	1.0	1.2	1.1	1.8
Limb area (in^2)/tree	*	16.6	28.2	28.7	*	15.1	18.1	22.7	129.7
No. limbs cut/ft pruned	3.8	3.3	3.5	2.8	3.3	3.0	2.4	2.7	2.7
Bole length pruned (ft)	3.5	4.2	4.2	4.8	5.4	6.1	5.8	7.2	17.0

* Not measured.

trees were larger than for half-height pruned trees (16.5 ft). For all treatments, crown width in a north-south direction was larger than in an east-west direction, where mean differences between directions were 4.9 ft for unpruned, 3.6 ft for 17-ft, 3.8 ft for third-height, and 2.9 ft for half-height treatments.

Pruning third and half heights is more severe than it might seem. Third-height pruning cut 56 percent of the branches, and half-height pruning cut 79 percent at the end of the 1st year. Throughout the study, third-height pruning removed fewer, larger limbs and so produced greater wound area per tree than did half-height pruning. The 17-ft pruning removed largest average limb size and produced largest aggregate wound area (table 2).

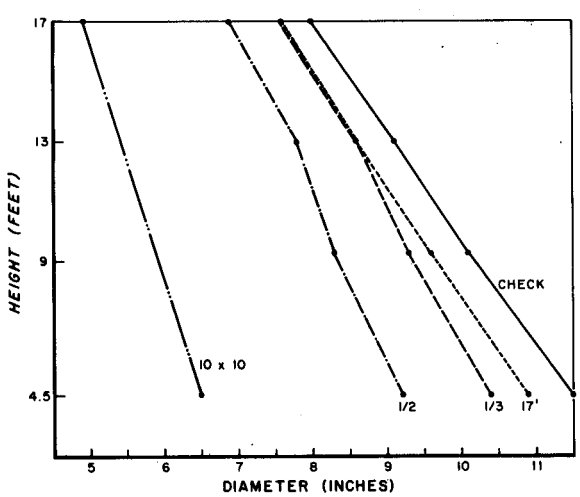

Figure 2.—*Average diameter at given stem heights for pruning treatments and for 10- by 10-ft spacing at age 5.*

Top breakage started in April of the 3d year. Proportion of trees with top breakage through 5 years was 0 for unpruned, 5 percent for third-height and 17-ft, and 23 percent for half-height pruning treatments. Storms caused breakage during the growing season. Stems snapped off from just below pruning height to 20 ft above. When one limb of a fork was pruned, the remaining limb was more likely to break. No signs were found of canker or borer damage on the broken tops.

In the 10- by 10-ft spacing, cottonwood averaged 1.2 inches d.b.h. and 11.5 ft tall after 1 year and 3.6 inches d.b.h. and 29.3 ft tall after 2 years. At age 5, trees averaged 6.5 inches d.b.h. (from 5.3 to 7.1 inches), 60.6 ft in height (from 56 to 65 ft), and 8.7 ft in maximum crown width (from 5 to 11 ft in either direction, 6.0 to 10.0 ft average of two directions). Average ratio of diameter at 17 ft to d.b.h. was 0.76 (from 0.72 to 0.79). All limbs to 17 ft were dead, and no natural pruning had occurred. Average ratio of live crown to total height was 0.32 (from 0.18 to 0.47).

DISCUSSION

As in earlier studies (Krinard and Johnson 1975), planted cottonwood has shown fast early diameter growth followed by a rapid drop in growth. For unpruned trees, diameter growth the 4th year was 75 percent of 3d-year growth; 5th-year growth was 75 percent of 4th-year growth and 56 percent of 3rd-year growth.

Where there was no pruning, trees at 40- by 40-ft spacing averaged 0.1 inch smaller d.b.h. and 0.8 ft shorter after 1 year, and 0.4 inch larger and 5.5 ft shorter after 2 years than trees at 10-

by 10-ft spacing averaged. After 5 years, the 10- by 10-spaced trees were 4.9 inches smaller in d.b.h. and 1.9 ft shorter in height than were trees in the 40- by 40-spacing. Maximum tree measurements were 12.6 inches in diameter and 67 ft in height for the 40- by-40, 6.5 inches in diameter and 65 ft in height for the 10-by-10.

To determine cubic-foot volume, I used mean values of trees whose upper stem diameters were measured, and d.b.h.^{2} times height times form as a cubic-foot volume indicator. Third-height pruned trees had 84 percent as much cubic-foot volume as unpruned trees had. Half-height pruned trees had 67 percent as much, 17-ft pruned trees had 88 percent as much, and trees at 10-by 10-ft spacing had 33 percent as much cubic-foot volume as unpruned trees had.

At the end of the 5th year, third- and half-height pruned trees had 73 percent and 57 percent as much crown as unpruned trees had, if crown length is considered crown size. If crown shape is considered conical, with the base an ellipse, then the lateral crown surface areas of third- and half-height pruned trees are only 59 percent and 39 percent as large as unpruned trees. Conical crown volumes are only 48 percent and 26 percent as large.

Crown length required for a given diameter growth cannot be determined from this study. For the 3d through 5th years, however, diameters of third-height pruned trees were 96, 93, and 90 percent as large as diameters of unpruned trees, while diameters of half-height pruned trees were 88, 84, and 81 percent as large.

Wide-spaced trees need pruning for quality growth. Pruning reduces diameter growth but not height growth. Because nearly a fourth of the half-height pruned trees suffered broken tops, half-height pruning is apparently too severe. Third-height pruning is more successful and results in only 1 inch (10 percent) less diameter in 5 years than half-height pruning produces. The 17-ft pruning produced results mathematically equal to those of third-height pruning. But boles and limbs pruned in the 17-ft treatment were larger than those pruned in the third-height treatment. So, 17-ft pruning produced a larger, lower quality core than did third-height pruning. Pruning was not effective in keeping branches off tree boles.

Although only one clone-type was used, and other types may have different crown shapes, unpruned trees of clone 66 maintained live limbs to the ground through 5 years. The widest part of an unpruned tree crown was generally near the bottom of the tree, and the crown tapered to the top. Maximum crown width measured in one direction was 30 ft for check and 29 ft for third-height pruned trees. Mean north-south crown widths were 27 ft. for check and 22 ft for third-height pruned trees. Cottonwood crowns do not mingle; so, as this study shows, a minimum spacing of 26–30 ft square is needed for maximum diameter growth through 5 years for trees receiving third-height pruning.

Cottonwood planted at 40 by 40 ft and pruned to a third of its height yearly can average 2 inches annual diameter growth through 5 years. Maintaining two-thirds of a crown has produced less diameter and stem volume than an unpruned tree would have but has improved tree form and quality. Growth over the next 5–10 years will determine the feasibility of producing sawlogs on a 10- to 15-year rotation. With wide spacing, intercropping seems a reasonable method of acquiring an early return to help offset clearing, planting, cultivating, and pruning costs.

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