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EFFECT OF NITROGEN FERTILIZER ON GROWTH, FORM, AND WOOD QUALITY OF EASTERN COTTONWOOD

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ABSTRACT: A 9-year-old cottonwood plantation near Fitler, Mississippi was fertilized with ammonium nitrate (150 and 300 lbs N/A) in May 1970. Fertilizer increased diameter (b.h.) growth of dominant, codominant, and intermediate crown classes by 109, 174 and 482 percent, respectively. Form class of fertilized trees also increased. On a whole-stem basis, specific gravity declined 3% following treatment. There did not appear to be any significant changes in fiber length due to fertilizer application. We concluded that positive effects of fertilization on volume growth far outweigh the slight reduction in specific gravity.

Crown Zellerbach's Fitler Managed Forest in Issaquena County, Mississippi is the largest cottonwood (Populus deltoides Bartr.) plantation in the United States. It supplies a major portion of the fiber requirements for CZ's groundwood pulpmill at St. Francisville, Louisiana. If growth and yield of cottonwood at Fitler Managed Forest could be enhanced by cultural practices, more company-grown wood could be supplied to the St. Francisville mill.

Previous studies by CZ's Southern Timber Division and the U. S. Forest Service indicated that radial growth of cottonwood could be accelerated greatly (100% or more) by application of nitrogen fertilizer (1, 8). With this magnitude of response there may be associated changes (beneficial and/or detrimental) in tree form and wood quality. Such changes may affect actual fiber volumes, mill processing costs, and quality of final products.

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Thus, the work reported in this note evaluated the effects of nitrogen fertilizer on some of these traits.

METHODS

The present study was conducted on a sub-sample of 27 trees obtained from a fertilizer trial established at Fitler Managed Forest in May 1970. At the time of fertilization, the stand was 9 years old, had good survival at a 9' x 10' spacing, but had been growing very slowly. Soils were Commerce sandy and silty loams (Mississippi Delta soils) with good physical properties, and had been previously cropped in cotton and beans. Response to applications of 150 and 300 lbs N per acre as ammonium nitrate was excellent and has been reported previously (8).

During the 1973 dormant season, the 27 sample trees were harvested -- 3 trees from each of three crown classes (dominant, codominant, and intermediate) in the control, 150 lbs, and 300 lbs N per acre treatments. Cross-sectional disks were cut at 4.5, 10.0, and 17.0 feet above ground. On each cross-section, radial growth was measured to the nearest 1/100-th inch for the 3 years prior to and 3 years after fertilizer application. Specific gravity was determined by the maximum moisture content method for wood produced during the above-named 3-year periods.

Length of wood fiber produced 3 years prior to and 3 years after fertilizer application was determined on cross-sections taken at 4.5 feet from a sub-sample of 12 trees (4 from each fertilizer treatment) which represented the range of growth rates. Fiber lengths were measured by TAPPI Standard Method T237, su-68.

The data were analyzed by standard variance and covariance techniques to determine the relationships of growth, form, and wood quality to ammonium nitrate levels. Results are summarized and discussed below under four sub-headings: diameter growth, form class, specific gravity, and fiber length.

RESULTS AND DISCUSSION

Diameter Growth

Nitrogen applications accelerated diameter growth greatly for trees of all crown classes. However, the relative growth response (i.e., in terms of percent) of codominant and intermediate trees was greater than for trees in the dominant crown class. Because this finding was unexpected and contrary to published results for other species (primarily conifers), we examined diameter growth response patterns of 15 additional trees in each treatment. Evaluation of the larger sample (24 trees per treatment) yielded

the same results (Table 1). Nitrogen fertilization of this cottonwood stand stimulated the lower crown classes to a relatively larger extent than the upper crown classes, thus increasing stand uniformity.

Table 1. Effect of Nitrogen Fertilizer on 3-year Diameter (Breast-High) Growth of Trees of Different Crown Classes.

	--Nitrogen Level--					
	0		150		300	
Crown Class	Diameter Growth	Response	Diameter Growth	Response	Diameter Growth	Response
	-inches-	-%-	-inches-	-%-	-inches-	-%-
Dominant	2.14	-	4.20	96	4.76	122
Codominant	1.29	-	3.12	142	3.94	205
Intermediate	0.62	-	3.75	505	3.46	458

Some foresters have speculated that fertilization of dense stands of conifers would accelerate the differentiation of crown classes and could in effect serve to thin a stand (6). Also, it has been established that intermediate trees do not show a growth response following N fertilization of a well-spaced loblolly pine plantation whereas dominant and codominant trees do respond (7). It appears from our work that such effects for well-spaced cottonwood are somewhat different. This finding merits additional testing; however, it is certainly compatible with Crown Zellerbach's objective of growing trees to a given age and clearcutting for groundwood bolts.

Form Class

The average form class of fertilized trees was greater than that of unfertilized trees (Table 2). Because form class was positively related to tree size, the more rapid growth (hence, larger size) of fertilized trees accounts for at least part of the form class differences. However, form class of trees of the same size (d.b.h.) was higher for fertilized trees than for unfertilized trees. The effect of form class improvement alone on volume three years after treatment is illustrated for the first 17-foot section of an average tree (4" d.b.h.) in Table 3. An added volume growth benefit of 4% or more is associated with improvement in form class.

Table 2. Effect of Nitrogen Fertilizer on Form Class.[1/]

Fertilizer Treatment	Form Class	Range in Form Class
Control	43 a	20-60
150	54 b	37-66
300	61 b	57-67

Table 3. Effect of Nitrogen Fertilizer on Form Class and Inside Bark Volume Contained in First 17' Section of a 4" d.b.h. Tree.

Fertilizer Treatment	Form[2/] Class	Volume[3/] Inside Bark (cu. in.)	Difference, %
Control	47	1405	
150	52	1455	4
300	60	1556	11

Specific Gravity

Differences in specific gravity after fertilizer application were analyzed by covariance, using specific gravity prior to treatment as the covariate. Wood samples taken at breast-height from fertilized trees had a slightly lower (4 to 5%) specific gravity than did samples from unfertilized trees (Table 4). Differences associated with fertilization were less for wood produced at upper stem positions: thus, on a weighted whole-stem basis (groundline to 17'), wood specific gravity of fertilized trees was only 3% less than wood of unfertilized trees.

1/ In this table and subsequent tables, means accompanied by different letters are significantly different at the 5% level.

2/ Form classes obtained by solving individual treatment regression equation $[FC = b_o + (d.b.h.)]$ for d.b.h. = 4". Equations were produced using data collected three years after treatment.

3/ Assumes double bark thickness of 0.5 inches at groundline and breast-height; assumes cylindrical shape for first 4.5' bolt, then uniform taper to 17'.

Einspahr and his associates (3) found that when radial growth of aspen was accelerated 56 percent by cultural treatments (fertilization and irrigation) specific gravity was lowered by 8.5 percent. On the other hand, no change in specific gravity was observed when a fertilizer-only treatment failed to stimulate breast-high diameter growth.

Table 4. Specific Gravity of Wood Formed for Three Years After Treatment.

Treatment	Sample Position		
	4.5'	10'	17'
Control	0.422 a	0.425 a	0.422 a
150	0.403 b	0.410 a b	0.412 a
300	0.401 b	0.406 b	0.414 a

The relationship between specific gravity and growth rate in cottonwood is not clear. Most workers have found a negative correlation (5), but others were not able to find any significant relationship (2, 4, 9). Such differences may result from interaction with genetic (5) and/or environmental factors. To evaluate such relationships in the present study, we conducted a subsidiary analysis relating growth rate of all trees during the 3-year period before fertilization to the specific gravity of wood laid down during this period. Although there was a wide range in both growth rate (2 to 18 rings per inch) and specific gravity (0.36 to 0.47), the variables were not significantly correlated. Thus, in our study, the reduced specific gravity subsequently associated with fertilization may not have been due to accelerated growth per se. Rather, it may have been linked to the nature of growth stimulation by fertilizer treatment.

Fiber Length

Average fiber lengths are shown for the 3-year periods before and after fertilizer treatments in Table 5. Based on this limited sub-sample, there does not appear to be any significant trend in fiber length changes due to fertilizer application.

Table 5. Whole Fiber Length Measured Before and After Fertilizer Application.

Fertilizer Treatment	Fiber Length	
	Before	After
	-------mm--------	
Control	0.86 a	0.90 a
150	0.91 a	0.91 a
300	0.90 a	0.92 a

SUMMARY AND CONCLUSIONS

1. Fertilizer applications accelerated the diameter growth of cottonwood. Because the relative growth response was greater in the lower crown classes, fertilization increased the uniformity of trees within the stand. This finding is at variance with results reported for coniferous species and merits further evaluation in cottonwood.

2. Form class increased with fertilizer application. This change resulted in an added volume benefit of 4% or more above what would be estimated from measurements of d.b.h. and height alone.

3. Whole-stem specific gravity decreased slightly (approximately 3%) as a result of fertilization.

4. Significant changes in fiber length could not be detected in the present study.

Therefore, we concluded that positive aspects of fertilization greatly over-ride the slight reduction in specific gravity. Fertilizer application to enhance growth rate of stands having similar characteristics (mensurational, site, soils) is highly recommended.

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