FERTILIZATION INCREASES GROWTH OF SAWLOG-SIZE YELLOW-POPLAR AND RED OAK IN WEST VIRGINIA

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Abstract

Sawlog-size even-aged hardwood stands in north-central West Virginia were fertilized with N, P, and K, singly and in combinations. Applications of N alone increased the annual basal area growth of yellow-poplar more than that of red oak during the first 7 years after fertilization, whereas P alone increased the annual basal area growth of red oak more than that of yellow-poplar. NP did not stimulate the growth of yellow-poplar more than did N alone and did not increase the growth of red oak more than did P alone. The 7-year cumulative basal area growth of yellow poplar was increased 34 percent by N, while that of red oak was increased 20 percent by P. NPK usually increased the growth of both species over that of the control trees, but usually not more than that of N or P, singly or combined. N fertilization could increase the 7-year volume growth of pure stands of sawlog-size yellow-poplar by about 30 percent in this region.

INTRODUCTION

Forest fertilization has been relatively common in this country since the early 1950s, and studies have been made to determine fertilizer rates for optimum tree growth. However, recent summaries of such studies in the United States and Canada point to the need for a greater understanding of the nature and distribution of nutrient deficiencies in the forest landscape (Krause 1973, Safford 1973, Auchmoody and Filip 1973, Leaf 1974).

Of equal importance are the economic aspects and effects on water quality of forest fertilization. Economics will ultimately dictate the extent to which forest fertilization will be used as a management tool, and water quality effects may further influence application methods and prescription criteria.

In this paper, I discuss the growth of sawlog-size yellow-poplar and red oak following N, P, and K fertilization. The trees were growing on Gilpin or Calvin soils in north-central West Virginia.

METHODS

The study was established in Tucker and Randolph Counties of north-central West Virginia. This area of rugged mountainous terrain receives about 140 cm of precipitation annually and has a frost-free period of about 150 days. Eleven independent study areas located in fully-stocked, even-aged hardwood stands 50 to 70 years old were used in this study. Soils in the areas are well- drained silt loams, about 90 cm deep to sandstone and shale bedrock, belonging to either the Gilpin or Calvin series (Typic Hapludults and Typic Dystrochrepts). The red oak site index for the areas ranged between 20 and 23 m.

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140 cm	=	55 in
90 cm	=	2.95 ft
20 m	=	65 ft
23 m	=	75 ft

Each area contained five plots ranging from .08 to .13 ha. The minimum distance between plots was 15 m, but this distance usually exceeded 46 m. Each plot contained 3 to 10 domimant or codominant yellow-poplar (*Liriodendron tulipifera* L.) or red oak (*Quercus rubra* L.) trees from 30 to 41 cm in diameter at 1.37 m (dbh). In all, 199 yellow-poplar and 78 red oak trees were used to measure the response to fertilization.

Each study tree was equipped with an aluminum band dendrometer at a height of 1.37 m; the diameter was recorded to the nearest .25 mm. Diameter measurements were taken each October for 5 years and again 7 years after fertilization (Fig. 1).

Four fertilizer treatments and the control were evaluated:

C	=	no fertilizer
P	=	224 kg P_2O_5/ha
N	=	336 kg N/ha
NP	=	336 kg N + 224 kg P_2O_5/ha
NPK	=	336 kg N + 224 kg P_2O_5 + 112 kg K_2O/ha

The fertilizers used were urea, triple superphosphate, and muriate of potash. Fertilizers were broadcast in early May 1970. Nitrogen and phosphorus were reapplied at the same rate in May 1971 to ensure their availability during the second growing season.

The basal area growth of individual trees was used to evaluate the treatments. The initial basal

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.08 ha	=	⅕ acre
.13 ha	=	⅓ acre
15.2 m	=	50 ft
45.7 m	=	150 ft
30.5 cm	=	12 in
40.6 cm	=	16 in
1.37 m	=	4.5 ft
.254 mm	=	.01 in
224 kg/ha	=	200 lb/acre
336 kg/ha	=	300 lb/acre
112 kg/ha	=	100 lb/acre

igure 1.—Sawlog-size yellow-poplar equipped ith dendrometers. Fertilization increased the nnual basal area growth.

area was used as a covariate to compensate for growth differences related to tree size. Basal area growth data were analyzed as a randomized complete block design with a control and four treatments in each block. There were seven yellow-poplar blocks and four red oak. Paired comparisons among the treatments were tested for significance at the .05 level using a Scheffé test.

RESULTS

The results of the first 3 years after fertilization were reported by Auchmoody and Smith (1977). In this paper, the growth patterns 4 to 7 years after fertilization are discussed, and the 7-year growth response is summarized.

Basal area growth

Yellow-poplar.—No statistically significant differences in the average annual basal area growth were found among the treatments for the 4th through 7th years after fertilization (Table 1). However, the average annual basal area growth of the N-fertilized trees was 28 percent more than that of the control trees, and the NP-fertilized trees, 23 percent more than that of the controls (Fig. 2).

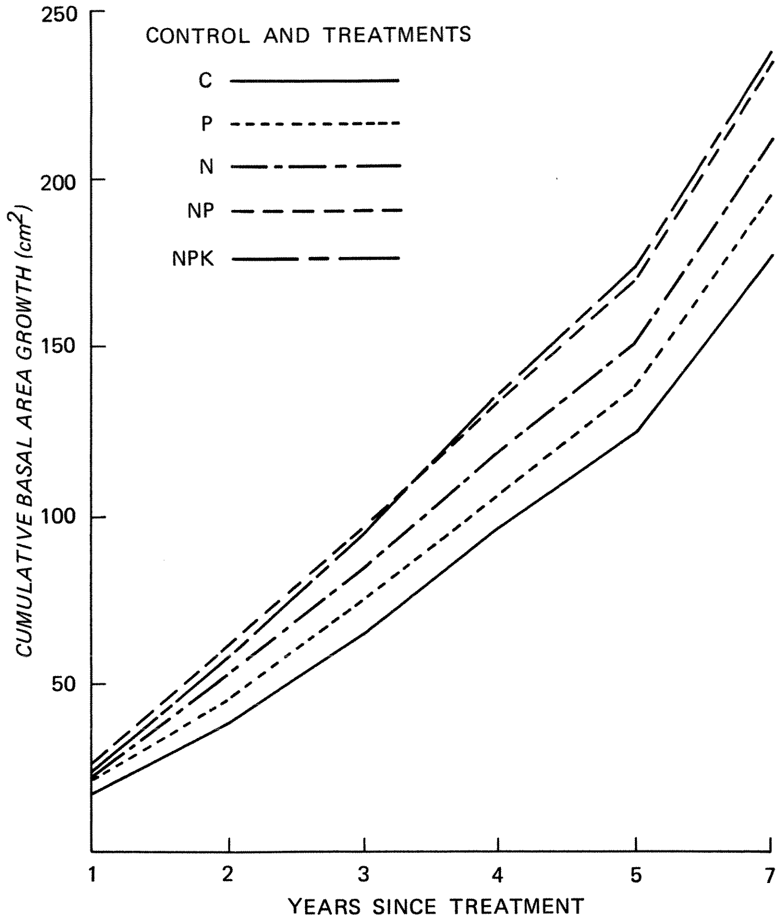
The fact that P, alone or in combination with N, had very little effect on the average annual basal area growth over that of the control trees or those fertilized by N shows that P is not limiting for yellow-poplar growth on these soils. The in-

Table 1.—Average basal area growth of yellow-poplar and red oak trees and percentage of increase after fertilization compared to unfertilized trees

Control and treatment	Yellow-poplar		Red oak	
	cm^2	%	cm^2	%
		1ST YEAR		
C	16.9a	—	19.5a	—
P	20.4a	21	26.7b	37
N	23.2a	37	24.3a	25
NP	25.7a	52	25.6b	31
NPK	21.2a	25	22.7a	16
		2ND YEAR		
C	22.3a	—	31.8a	—
P	25.7a	15	38.4a	21
N	34.9b	56	41.2a	30
NP	34.9b	56	43.4a	36
NPK	31.4a	41	39.4a	24
		3RD YEAR		
C	25.6a	—	36.8a	—
P	28.1a	10	43.1a	17
N	36.2b	41	44.8a	22
NP	35.2b	38	48.2a	31
NPK	31.1a	21	45.3a	23
		4TH YEAR		
C	32.33a	—	43.29a	—
P	31.96a	−1	47.75a	10
N	40.69a	26	45.80a	6
NP	38.18a	18	46.73a	8
NPK	35.39a	9	45.24a	5
		5TH YEAR		
C	27.78a	—	40.59a	—
P	32.89a	18	49.89a	23
N	37.72a	36	43.57a	7
NP	35.86a	29	43.85a	8
NPK	31.40a	13	39.02a	−4
		7TH YEAR		
C	26.85a	—	40.50a	—
P	27.78a	3	46.64a	15
N	32.89a	22	40.50a	0
NP	33.07a	23	45.15a	12
NPK	29.91a	11	35.58a	−12
		1 TO 7 YEARS		
C	178.61a	—	252.98a	—
P	194.61a	9	299.12a	18
N	238.49a	34	280.67a	11
NP	235.98a	32	298.08a	18
NPK	210.31a	18	262.82a	4

Values in columns followed by the same letter are not significantly different at the 0.05 level.

Figure 2.—Cumulative basal area growth of yellow-poplar.



creased growth of the NP-fertilized trees was apparently due to the N.

The total basal area growth for the 7-year period indicated a response to N and NP fertilization, but no statistically significant differences were found among treatments. N and NP fertilization increased the total basal area growth for the 7-year period by 34 and 32 percent.

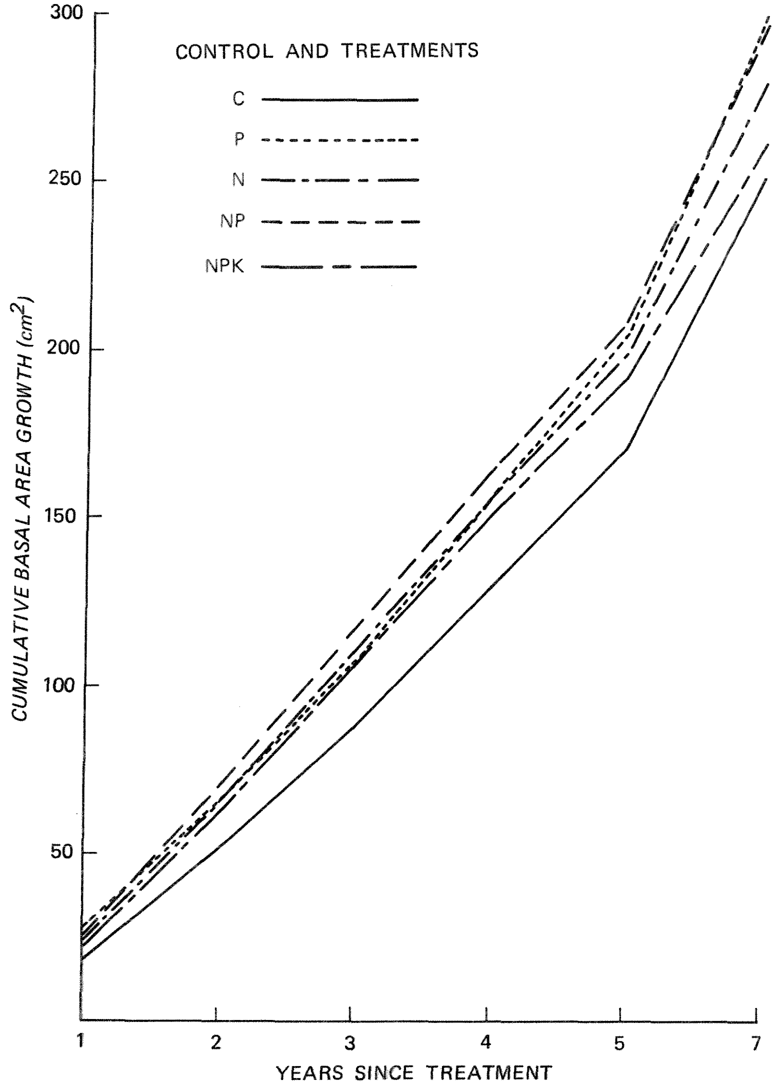
Annual basal area growth of NPK-fertilized trees averaged about 11 percent more than that of the control trees during the 4-year period. The 7-year periodic basal area growth following NPK treatment was only 18 percent more than that of the control. Similar trends were observed by Auchmoody and Smith (1977) during the first 3 years following treatment (Table 1). The reasons for NPK-fertilized trees growing less than N- or NP-fertilized trees are not clear.

Red oak. Red oak was less responsive to treatment than yellow-poplar. Although no statistically significant differences were found among the treatments for the 4th through 7th years, P increased the annual basal area growth an average of 16 percent over that of the control trees; NP, 9 percent; and N, 4 percent (Table 1). The growth response to fertilization was P > NP > N > C > NPK for the 4th through 7th years after treatment. P fertilization continued to increase red oak basal area growth 7 years after treatment (Fig. 3). It appears that most of the response to N fertilization was in the first 3 years

The P, N, and NP treatments increased the 7-year basal area growth 18, 11, and 18 percent. Although no statistically significant differences were found among the treatments, the response to P is evident.

The NPK treatment usually resulted in less average annual basal area growth than did the P, N,

Figure 3.—Cumulative basal area growth of red oak.



and NP. In fact, during the 4th through 7th years, the NPK treatment resulted in about 4 percent less growth than that of the control trees.

DISCUSSION

The lack of statistically significant differences among the treatments was probably due to the high variation both within and among blocks. A less conservative test than the Scheffé might have declared more means significantly different.

The relative basal area growth of yellow-poplar in response to N fertilization can be seen in Figure 4. This growth was greatest 2 years after treatment, then it generally declined. The fact that the growth of the P-fertilized trees was only slightly greater than that of the controls shows that the increased growth following NP fertilization probably resulted from the N.

The relative basal area growth of the P-fertilized red oak was about the same as that of the N- and NP-fertilized trees during the first 3 years after treatment, and greater during the 4th through 7th years after treatment (Fig. 5).

This study did not include an analysis of Gilpin and Calvin soils, but our data on diameter growth

Figure 4.—Relative basal area growth of yellow-poplar.

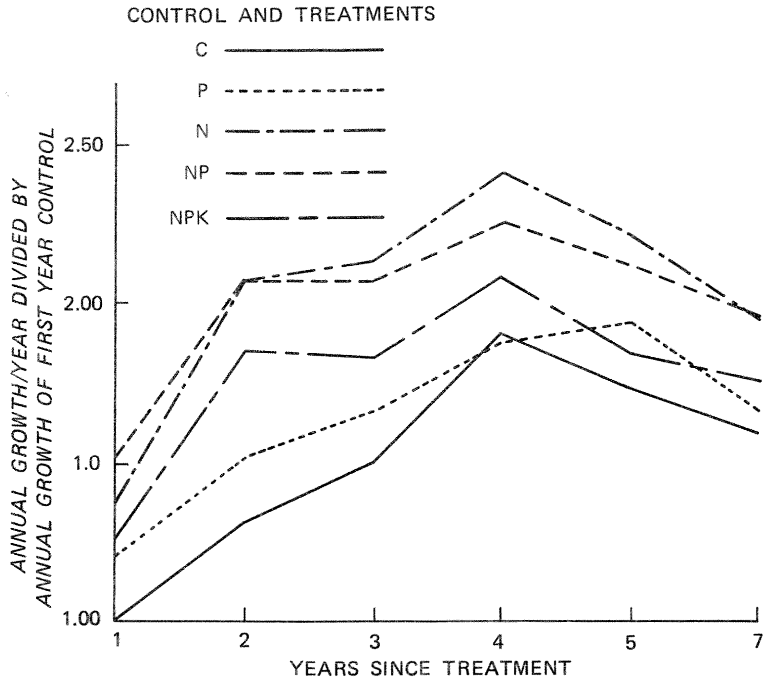
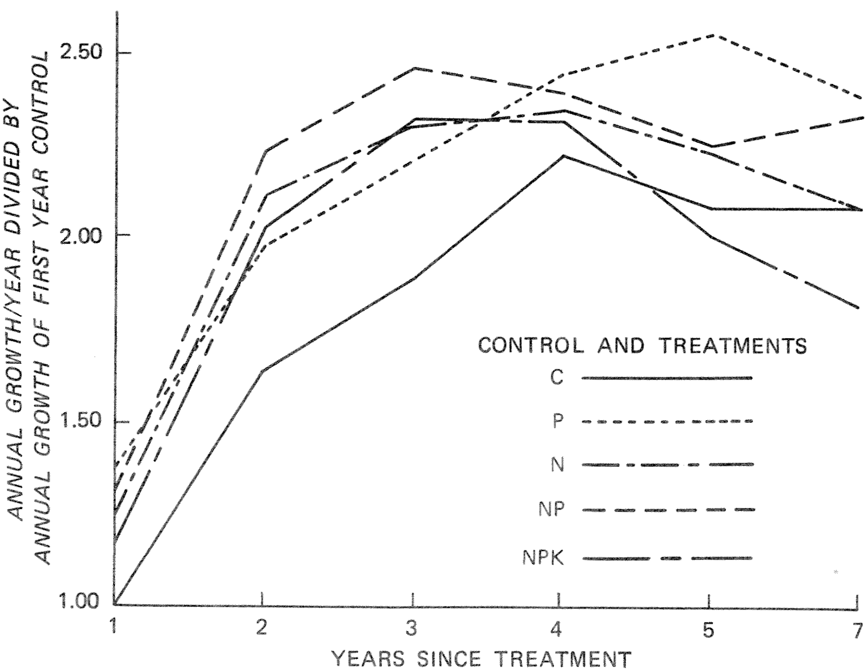


Figure 5.—Relative basal area growth of red oak.



following fertilization suggest that these soils are deficient in nitrogen for the maximum growth of yellow-poplar, and in phosphorus for red oak.

Although nearly pure stands were studied, only the dominant and codominant trees were measured, so data per hectare are lacking. However, nearly all the volume growth in a sawlog-size stand occurs in the dominant and codominant trees. Thus, the observed 34 percent increase in the growth of N-fertilized yellow-poplar would result in at least a 30 percent increase in the volume growth of the stand.

The expected 7-year volume growth for yellow-poplar stands on sites similar to those in this study is 12.25 m^3/ha. Our study indicates that this volume could be increased to 15.92 m^3/ha, or about 30 percent, by the N treatment. The average diameter of the yellow-poplars was 38 cm dbh before fertilization, and normal growth is about 4 annual rings per cm. This growth rate could be increased to about 3 annual rings per cm by N fertilization.

CONCLUSIONS

Following the fertilization specifications set up for this study in West Virginia:

The average annual and the 7-year cumulative basal area growth of N-fertilized yellow-poplar trees was 36 percent more than that of control trees. The N treatment could be expected to increase the 7-year volume growth of sawlog-size yellow-poplar stands by at least 30 percent.

The average annual and cumulative basal area growth of P-fertilized red oak trees was 20 and 18 percent more than that of the control trees.

The application of N increased the basal area growth of yellow-poplar more than that of red oak, while the application of P increased the basal area growth of red oak, more than that of yellow-poplar.

The application of NP did not increase the growth of yellow-poplar more than N alone, and did not increase the growth of red oak more than P alone.

Fertilization with NPK generally increased the growth of both species—though not substantially—over that of the control trees, but usually not more than that of N or P applied singly or combined.

38.1 cm	=	15 in
4 rings/cm	=	10 rings/in
3 rings/cm	=	7.8 rings/in
12.25 m^3/ha	=	2,100 fbm/acre
15.92 m^3/ha	=	2,730 fbm/acre

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