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# FERTILIZER RESPONSE AND BIOMASS ACCUMULATION OF A 5-YEAR-OLD SWEETGUM PLANTATION[1/]

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Abstract.--A sweetgum plantation was established in 1975 to evaluate the effects of N, P fertilizers on growth and biomass accumulation. Positive response to the N and, to a lesser degree, the N + P treatment were noted the first year after fertilization. At age 5, total biomass averaged 2.5 T/ha: 25% leaves, 25% branches and 49% stems. Biomass accumulation was 50% greater on N treated plots than control.

## INTRODUCTION

Earlier trends and projections from wood using industries indicated an increasing demand for hardwoods in the South. Hardwood plantations have been established in recent years to meet such demand by Corporations mainly in the fertile alluvial valley of the Mississippi River. Since land clearing for farming has been proceeding steadily, the best sites available for hardwood timber production has diminished in the area. It is necessary, therefore, to turn to other sites for possible hardwood production.

In 1974, a cooperative study between the Department of Forestry, University of Arkansas at Monticello and USDA-Forest Service was initiated to evaluate the potential production of hardwoods on a moderately poor silty upland site, a part of the University Experiment Forest. Sweetgum (Liquidambar styraciflua L.) was selected since it is one of the endemic hardwoods and a desirable species for both pulping and solid wood uses. Because of the inherent slow growth of the sweetgum coupled with the low fertility of the soil, the objective of the study was to evaluate the effects of fertilizers on growth, nutrient accumulation and biomass production of planted sweetgum on a marginal hardwood site. This paper will not report the nutrient status since chemical analyses are incomplete.

## METHODS

An old field of poorly-drained Henry silt loam, a coarse-silty, mixed, thermic, Typic Fragiaqualf was cleared of heavy brush and disked three times in late 1974. One-year-old sweetgum seedlings from an Arkansas source were hand-planted in February 1975, at 2.75 M x 2.75 M spacing. Fifty seedlings in 10 rows of 5 trees each were planted in each plot. The interior 24 trees were used as measurement trees to evaluate growth and stand development.

The statistical design was 6 randomized blocks of 4 fertilizer treatments: N, P, N + P and Control. Fertilizers were applied by a tractor drawn 4-foot-wide spreader in March, 1979 (at plantation age 4) at the rates of 280 Kg N, 168 Kg P, 280 Kg N + 168 Kg P per ha. No fertilizer was added on control plots.

Machine cultivation was maintained during the first two growing seasons to control competing vegetation. Survival of the planted seedlings was 81% at the end of the first growing season and they averaged 42 cm in total height.

Since 1977, the following measurements were taken: total height, diameter at 30 cm above ground, crown length and crown width. Beginning with the 1979 measurement, additional diameter at breast height measurement was taken when trees averaged more than 3 meters in height

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In October 1977, one sample tree from each plot using the mean tree technique,[3/] (a total of 24 trees) was harvested by shearing at the ground level for biomass and nutrient analysis. Each tree was separated into the following components: leaves, current branches, old branchwood, old branchbark, stemwood, and stembark. Components were weighed fresh and again after oven-drying at 70°C.

In October 1979, one growing season after fertilizer treatment, 6 trees from each treatment (one tree from each plot) covering entire ranges of height and diameter (dbh) were harvested. The change of population sampling technique was necessary to accommodate a greater range of tree sizes resulting from advanced stand development and crown differentiation.

## RESULTS AND DISCUSSION

### Fertilizer Response

Average values in height, diameter at 30 cm above ground, crown length and crown width for two years prior to fertilization (1977, 1978) and one year after fertilization (1979) are presented in Table 1. The sweetgum grew slowly at first. For the last year before fertilizer treatment (1978), the annual increments were: 92 cm in height, 1.1 cm in diameter at 30 cm above ground, 96 cm in crown length and 27 cm in crown width. It appeared that none of the average values of the intended treatment plots were significantly different prior to fertilizer treatment.

Measurements in 1979, one growing season after fertilizer treatment, showed that N and N + P plots made significantly more growth than Control or P only plots. On the average, treatments containing N increased height growth by nearly 30%, diameter growth by 25%, crown length by 20% and crown width by 61% (Table 2).

### Biomass Accumulation

From the 1979 harvest, linear regression equations were derived from dry weights of felled trees in each treatment to estimate biomass accumulation for that treatment. The regression equations followed the general form:

$$W = A + B\ (D^2H)$$

where W is the predicted biomass dry weight of individual tree, grams.
D is the dbh of the tree, mm.
H is the total height of the tree, cm.
A and B are the intercept and slope of the regression line.

Table 1.--A comparison of average height, diameter, crown length and crown width between fertilizer treatments.

| Treatment | Height | | | Diameter at 30 cm | | | Crown length | | | Crown width | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | cm | | | | | | | | | | | |
| | '77 | '78 | '79 | '77 | '78 | '79 | '77 | '78 | '79 | '77 | '78 | '79 |
| N | 163 | 259 | 353* | 2.2 | 3.3 | 5.1** | 135 | 233 | 318** | 83 | 113 | 150* |
| P | 162 | 257 | 329 | 2.2 | 3.4 | 4.8 | 135 | 235 | 292 | 83 | 111 | 138 |
| N+P | 159 | 245 | 341 | 2.0 | 3.0 | 4.7 | 132 | 220 | 299 | 77 | 100 | 137 |
| C | 155 | 247 | 321 | 2.0 | 3.2 | 4.6 | 123 | 219 | 287 | 81 | 107 | 130 |
| Mean | 160 | 252 | 336 | 2.1 | 3.2 | 4.8 | 131 | 227 | 299 | 81 | 108 | 139 |

** $P < 0.01$
* $P < 0.05$

[3/] Crow, T. R. 1971. Estimation of biomass in an even-aged stand--regression and "mean tree" techniques. in Forest Biomass Studies, XVth IUFRO Congress, University of Maine. pp 35-48.

Table 2.--First Year Growth Response to Fertilizer Treatments.

| Treatment | Height | | Diameter at 30 cm | | Crown length | | Crown width | |
|---|---|---|---|---|---|---|---|---|
| | cm | % | cm | % | cm | % | cm | % |
| N | 94* | 27 | 1.8** | 29 | 85* | 24 | 37** | 61 |
| P | 72 | -- | 1.4 | -- | 57 | -- | 27 | 17 |
| N+P | 96* | 30 | 1.7 | 21 | 79 | 16 | 37** | 61 |
| C | 74 | | 1.4 | | 68 | | 23 | |

** P < 0.01
* P < 0.05

Table 3.--Parameters of Biomass Prediction Equation by Fertilizer Treatments-1979 Harvest.

| Treatments | Intercept (A) | Slope (B) | $r^2$ |
|---|---|---|---|
| N | 505.3266 | .5629 | .90 |
| P | 734.3317 | .5202 | .81 |
| N+P | 121.1416 | .6913 | .99 |
| C | 611.4199 | .4577 | .85 |

Table 4.--First Year Response of Biomass Accumulation by Fertilizer Treatments.

| Treatment | Biomass | | | | Periodic Increment | | Periodic Annual Increment |
|---|---|---|---|---|---|---|---|
| | 1977 | | 1979 | | | | |
| | T/ha | % | T/ha | % | T/ha | % | T/ha |
| N | 0.461 | 33 | 2.976* | 48 | 2.515* | 51 | 1.258* |
| P | 0.496 | 43 | 2.688 | 34 | 2.192 | 32 | 1.096 |
| N+P | 0.424 | 22 | 2.513 | 25 | 2.089 | 26 | 1.045 |
| C | 0.346 | -- | 2.007 | -- | 1.661 | -- | 0.830 |
| Mean | 0.432 | | 2.546 | | 2.114 | | 1.057 |

*P < 0.05

From the regression equation constants presented in Table 3, biomass of each tree was calculated and summarized in Table 4.

Results from biomass sampling of 24 trees harvested in 1977 indicated these 3-year-old sweetgums have accumulated 0.432 T/ha of biomass (Table 4) with the following distribution of tree components: leaves 35%, branches 23% and stems 42% (Table 5).

On the biomass distribution of tree components as trees develop and age, there is apparently a shift toward greater accumulation in stems (Table 5). Foliage diminished from 35% of the total biomass at age 3 to only 25% at age 5, an indication of increased photosynthetic efficiency with a greater accumulation of usable biomass in woody stems.

At age 5, biomass accumulation was 3 T/ha in N plots, 50% greater than the 2 T/ha accumulated in control plots. The periodic increment between age 3 and 5 was 1.26 T/ha/yr for the N plots and 0.83 T/ha/yr for the control. Total biomass averaged 2.5 T/ha for all plots. Additional analysis will be made to relate nutrient content and biomass to fertilizer treatments when nutrient data become available.

Table 5.--Change of Biomass Accumulation (%) by Tree Components With Time.

| Tree Components | 1977 | 1979 |
|---|---|---|
| Leaves | 35 | 25 |
| New branches | 11 | 4 |
| Old branches | 12 | 22 |
| Crown | 58 | 51 |
| Stemwood | 35 | 42 |
| Stembark | 7 | 7 |
| Stems | 42 | 49 |
| Total | 100 | 100 |