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Fertilization of Unthinned Loblolly Pine on an Intensively Prepared Cut-over Site in Twiggs County, Georgia: Four Year Results

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ABSTRACT

Objectives addressed in this study are: (1) would this relatively fast growing stand respond to NP or NPK fertilization, (2) is potassium needed (over N and P), (3) would there be an increase in pine straw production with fertilization, and (4) would it be financially attractive to fertilize? The questions of interest are: *(1) Does fertilization using NP or NPK improve stand performance?* Four year loblolly pine diameter increment was increased by 0.24 and 0.34 inches with the NPK and NP fertilization treatments, respectively. Total volume per acre was increased by an average of 183 and 235 cubic feet per acre for the NPK and NP fertilization treatments, respectively. Pine straw production was increased by 178 for the NP treatment and 260 bales/acre for the NPK treatment over the control plot means. *(2) Is potassium needed over N and P alone?* In this case, there does not appear to be a significant benefit to adding K, increasing P by 25 lbs/ac or N by 15 lbs/ac over the 185 N + 25 P lbs/ac application level over the four year period. Using the older standard "sufficiency" value of 0.35% for K and with soil available P in the range of 38 to 52 lbs/ac, it appears that (a) K was not need at this point in the life of this stand and (b) 25 lbs/ac of P was sufficient and 50 lbs/ac P did not improve growth. *(3) Would there be an increase in pine straw production with fertilization?* Pine straw production was increased by 178 for the NP treatment and 260 bales/acre for the NPK treatment over the control plot means during the 3 rake cycle. *(4) Would it be financially attractive to fertilize?* The NP and NPK treatments increased in wood+straw value by $225 and $229 per acre over the unfertilized loblolly pine value, respectively.

INTRODUCTION

Many private non-industrial forest landowners in Georgia are interested in fertilizing their pine stands. This study was established in Twiggs County, Georgia on the property of a private landowner. Working with Ted Wynne, UGA Extension Agent, the investigator install a fertilizer trial in an unthinned loblolly pine stand. The study was designed to answer the following questions: (1) would this relatively fast growing stand respond to NP or NPK fertilization?; (2) is potassium needed (over N and P)?; (3) would there be an increase in pine straw production with fertilization?; and (4) would it be financially attractive to fertilize?

Photo 1. 11 year-old loblolly pine stand

Stand and Site Characteristics

An unthinned 11-year-old loblolly pine stand (Photo 1) was chosen as the study area. The site, formerly in trees, was clear-cut in 1987 and intensively site prepared with stumps removed prior to planting in 1988. Loblolly pine seedlings were planted on a 6 feet by 10 feet spacing (728 trees/acre). Soil series of this site were verified by the Natural Resources Conservation Service as Norfolk and Orangeburg (Typic Kandiudults), and are considered productive soils to grow southern pines. Four ¼ acre plots each were treated in February 1999 with either (1) no fertilizer (control), (2) 185 N + 25 P, or (3) 200 N + 50 P + 50 K (nutrients described on an elemental basis) per acre. Diammonium phosphate (18-46-0), urea (46-0-0), and muriate of potash (0-0-60) were the fertilizers used and broadcast applied by a tractor and cyclone spreader.

Twelve permanent measurement plots (1/10th acre each) were installed within the fertilized and unfertilized areas in July 2000. All living loblolly pine trees were aluminum tagged and numbered, measured for diameter (Photo 2) at 4.5 feet above ground d.b.h., total height, and height to base of live crown for percent live crown determination in July 2000, May 2002, and December 2003. Total volume, pulpwood (PW; trees with a 4.6 to 6.5 inch d.b.h.), superpulp (SP; trees with a 6.6 to 8.5 inch d.b.h.), and chip-n-saw (CNS; trees with a > 8.5 inch d.b.h.) volume per acre were estimated using volume equations developed at the University of Georgia Warnell School of Forest Resources. Soil and foliage samples (taken in winter) and leaf area estimates (estimated in July – August) were collected during the study period (Table 1). Stand parameter means and increments were tested for statistical differences (ANOVA and Duncan's Multiple Range Procedure @ the 5% alpha level). The site was kept very clean of woody and herbaceous weeds prior to and during the study period with herbicides. The stand would be raked for pine straw starting in the spring of 2001.

Photo 1. Measuring DBH

RESULTS

Foliar, soil, and leaf area estimates

Table 1 illustrates that foliar nitrogen (N) concentration was above sufficiency (Allen 1987, Jokela 2004) during the study period. Nitrogen concentration in the foliage can be above sufficiency but if crown development is below adequate to optimal then wood and pine straw production is going to be below optimal. Leaf area estimates, a better indicator of N needs, were taken in 29 August 1999 (about 3 weeks past peak LAI due to droughty growing season) ranged from 1.4 to 2.4 indicating a potential response to the addition of N. Foliar P was close to sufficiency (0.12%) during the study period. Foliar K, using more recent NCSU Forest Nutrition Coop sufficiency value for K (0.40%) was slightly below sufficiency in 1999, 2002 for all treatments, but slightly above sufficiency for the NP and NPK plot trees in 2003. When using pre-1998 loblolly pine foliar "sufficiency" values for K (0.35%), foliar K was sufficient in all but the 2002 collection time in the control plot trees. Foliar boron (B) and copper (Cu) were also below sufficiency (below 10 and 3 ppm, respectively) in the control and NPK treatment plot

trees in December 2003. Soil available phosphorus (P) was above sufficiency (> 12 lbs/ac using the procedure @ UGA) throughout the study period.

Tree growth

The unthinned loblolly pine stand was growing at a vigorous rate through mid-year 1999. Trees per acre ranged from 665 to 685 in July 1999. Mean dbh ranged from 5.8 to 6.1 inches, basal area ranged from 131 to 138 ft^2/ac, total heights from 34.8 to 35.8 feet, and total volume/acre from 2214 (NP plots) to 2396 (control plots) ft^3/ac (Table 2). This equates to an annual basal area growth of over 12 ft^2/ac, height growth of over 3 feet, and volume growth of 210 ft^3/ac (2.38 cds/ac/yr or 6.4 tons/ac/yr). Fertilizer treatment mean trees/acre, diameter, basal area, total height, total volume, PW, SP, and CNS volumes/acre were not significantly different in July 1999, May 2002, and December 2003 (Table 2).

When looking at growth increment, diameter, basal area, height, and total volume/acre were generally significantly greater for the NP and/or the NPK when compared to the control between July 1999 and May 2002, May 2002 and December 2003, and from July 1999 and December 2003 (Table 3). The most significant growth increment gains occurred in the first three years after fertilization (Table 3). This may be the case for two reasons: (1) a larger time increment during the 11 to 14-year period and (2) due to the high basal area the stand had when the fertilizer was applied (131 to 138 ft^2/ac) the fertilizer incremental gain was greatest in the initial period.

Pine straw production

The first pine straw raking occurred in the spring of 2001 (age 13-years). An average of 273 bales per acre was raked from the control (no fertilizer) plots, 350 bales/acre from the NP plots, and 365 bales/acre from the NPK plots in 2001 (Figure 1). There were 232 bales/acre raked from the control plots in 2002 and 325 bales/acre raked from the NP and NPK plots. There was no data from the plots in 2003. In April 2004, an average of 360 bales/acre were raked form the control plots, 368 bales/acre from the NP plots, and 435 bales/acre from the NPK plots (Figure 1). The total bales/acre production gain from fertilization (2001, 2002, and 2004 rakes) was 178 for the NP treatment and 260 for the NPK treatment compared to the control plot means.

ECONOMICS OF FERTILIZATION

Extra wood gains

Using Timber Mart South (TM-S) 2004 GA stumpage prices of $16/cd for PW, $30/cd for SP, and $70/cd for CNS, the control (no fertilizer) treatment had a per acre value of $607 ($177 in PW, $417 in SP and $13 in CNS per acre) in July 1999. The control plot loblolly pine average wood value per acre in December 2003 was $1345 ($134 in PW, $745 in SP, and $467 in CNS per acre). This value increase between July 1999 and December 2003 in the unfertilized loblolly pine plots was $738 per acre.

The 185 N + 25 P lbs per acre treatment had a per acre value of $495 ($213 in PW, $271 in SP and $11 in CNS per acre) in July 1999. The NP loblolly pine average wood value per acre in December 2003 was $1413 ($124 in PW, $740 in SP, and $549 in CNS per acre). This value

increase between July 1999 and December 2003 in the unfertilized loblolly pine plots was $918 per acre, a gain of $180 per acre in wood value increment over the unfertilized loblolly pine. The 200 N + 50 P + 50 K lbs per acre treatment had a per acre value of $533 ($195 in PW, $326 in SP and $12 in CBS per acre) in July 1999. The NPK loblolly pine average wood value per acre in December 2003 was $1435 ($159 in PW, $621 in SP, and $655 in CNS per acre). This value increase between July 1999 and December 2003 in the unfertilized loblolly pine plots was $902 per acre, a gain of $164 per acre in wood value increment over the unfertilized loblolly pine.

Extra pine straw gains

Using an average price of $0.25 per bale paid to the landowner during the rake cycles (2001, 2002, and 2004) the NP treatment increased pine straw revenues by $45/acre over the control revenues. The NPK treatment increased pine straw revenues by an additional $65.00/acre during the same time period.

Extra wood and pine straw gains

The NP treatment increased the 4-year wood value increment by $180/acre over the unfertilized loblolly pine plots. The NP treatment increased pine straw revenues by $45/acre compared to the unfertilized pine straw plots. Therefore, the NP treatment increased total value (wood+straw) by $225/acre over the unfertilized loblolly pine.

The NPK treatment increased 4-year wood value increment by $164/acre over the unfertilized loblolly pine plots. The NPK treatment increased pine straw revenues by $65/acre compared to the unfertilized pine straw plots. Therefore, the NPK treatment increased total value (wood+straw) by $229/acre over the unfertilized loblolly pine.

Calculating Internal Rate of Return (IRR)

A. IRR using Fall 2002 fertilizer + application prices:

Costs: 185 N + 25 P (353 urea + 125 DAP @ $0.06/lb, $0.11 urea/lb and $0.10 DAP/lb = $78/acre) 200 N + 50 P+ 50 K (335 urea + 250 DAP + 100 MOP @ 0.08/lb = $110/acre)

►IRR for NP treatment = $((225/78)^{1/4} - 1) \times 100 = 30.2$ %

►IRR for NPK treatment = $((229/110)^{1/4} - 1) \times 100 = 20.1$%

B. IRR using Fall 2005 fertilizer + application prices:

Costs: 185 N + 25 P (353 urea + 125 DAP @ $0.07/lb, $0.21 urea/lb and $0.15 DAP/lb = $126/acre) 200 N + 50 P+ 50 K (335 urea + 250 DAP + 100 MOP @ 0.14/lb = $170/acre)

►IRR for NP treatment = $((225/126)^{1/4} - 1) \times 100 = 15.6$ %

►IRR for NPK treatment = $((229/170)^{1/4} - 1) \times 100 = 7.7$ %

SUMMARY

(1) **Did fertilization using NP or NPK improve stand performance?** In this case, the two fertilizer treatments improved stand performance over the four-year period. Loblolly pine diameter growth increased by 0.24 and 0.34 inches with the NPK and NP fertilization treatments,

respectively. Total volume per acre was increased by and average of 183 and 235 cubic feet per acre (5.5 and 7.1 tons per acre) for the NPK and NP fertilization treatments, respectively.

(2) **Is potassium needed over N and P alone?** In this case, there does not appear to be a significant benefit to adding K; increasing P by 25 lbs/acre; or N by 15 lbs/acre over the N+P application over the four year period. Using the older standard "sufficiency" value of 0.35% for K, and with soil available P in the range of 38 to 52 lbs/ac, it appears that (a) K was not need at this point in the life of this stand and (b) 25 lbs/ac of P was sufficient and 50 lbs/ac P did not improve growth.

(3) **Would there be an increase in pine straw production with fertilization?** Pine straw production was increased by 178 bales/acre for the NP treatment and 260 bales/acre for the NPK treatment over the control.

(4) **Would it be financially attractive to fertilize?** The NP and NPK treatments increased in wood+straw value by $225 and $229 over the unfertilized loblolly pine value, respectively. The internal rate of return (IRR) for the NP and NPK treatments using fall 2002 fertilizer prices is 30.2% and 20.1%, respectively. The internal rate of return (IRR) for the NP and NPK treatments using fall 2005 fertilizer prices is reduced to 15.6% and 7.7%, respectively, still and attractive internal rate of return for the NP treatment with 2005 fertilizer prices.

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CITATION

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Table 1. Foliar nutrient and soil available P levels prior to fertilization, one, and four years post application in an unthinned cut-over site loblolly pine plantation in Twiggs County, GA (Norfolk and Orangeburg soils).

		----------Foliage----------								
Fertilizer treatment	Year	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	S (%)	B (ppm)	Cu (ppm)	Soil P (lb/ac)
	1999									
Control		1.33	0.12	*0.37*	0.18	0.10	0.16			38
185N+25P		1.42	*0.11* [a]	*0.39*	0.15	0.10	0.12			52
200N+50P+50K		1.47	0.13	*0.36*	0.17	0.13	0.13			46
	2000									
Control		1.27	*0.11*	*0.27*	0.20	0.11	0.16			34
185N+25P		1.48	0.12	*0.37*	0.18	0.10	0.15			23
200N+50P+50K		1.53	*0.11*	*0.35*	0.22	0.09	0.16			43
	2004									
Control		1.23	0.12	*0.35*	0.20	0.09	0.16	*9*	*< 1*	26
185N+25P		1.32	0.12	0.40	0.19	0.10	0.16	13	3	36
200N+50P+50K		1.26	0.12	0.42	0.17	0.08	0.15	*10*	*< 1*	61

[a] Foliar nutrients in *italics* are at or below sufficiency for loblolly pine (Allen 1987, Jokela 2004).

Table 2. Growth parameter means at fertilization (age 11 years-old), three, and four years post application in an unthinned cut-over site loblolly pine plantation in Twiggs County, GA (Norfolk and Orangeburg soils).

Fertilizer treatment	Age (years)	Trees per acre	Dbh (in)	Basal area (ft2/ac)	Height (ft)	Total volume (ft^3/ac)*	PW‡ volume (ft^3/ac)*	SP ‡ volume (ft^3/ac)*	CNS ‡ volume (ft^3/ac)*
	11								
Control		665	6.1	138	35.9	2396	953	1195	16
185N+25P		685	5.8	131	34.8	2214	1145	777	14
200N+50P+50K		665	5.9	131	35.2	2238	1046	935	15
	14								
Control		660	6.6	161	40.6	3095	704	1833	273
185N+25P		673	6.5	161	42.2	3227	930	1683	299
200N+50P+50K		658	6.6	164	40.2	3122	778	1562	470
	15								
Control		660	6.8	176	45.8	3792	722	2131	574
185N+25P		665	6.9	181	45.5	3849	669	2118	675
200N+50P+50K		648	6.9	176	46.5	3817	854	1781	805

‡ PW = pulpwood; trees wit ha dbh of 4.6 to 6.5 inches, SP = superpulp; trees with a dbh of 6.6 to 8.5 inches, and CNS = chip-n=saw trees with a dbh > 8.5 inches.

* ft^3/ac = cubic feet per acre; 88 ft^3 = 1 cord of wood+bark, and 100 $ft^3 \approx 3$ tons.

Table 3. Growth parameter increment means between at fertilization and three years later (age 11- through 14 –years-old), between three and four years later (age 14 through 15-years-old), and between at fertilization and four years later (ages 11- through 15-years-old) in an unthinned cut-over site loblolly pine plantation in Twiggs County, GA (Norfolk and Orangeburg soils).

Fertilizer treatment	Age	Dbh (in)	Basal area (ft2/ac)	Height (ft)	Total volume (ft^3/ac)*	PW‡ volume (ft^3/ac)*	SP‡ volume (ft^3/ac) *	CNS ‡ volume (ft^3/ac)*
	11–14							
Control		0.49 b#	23 b	4.7 b	699 c	- 249	638	257
185N+25P		0.69 a	30 a	7.4 a	1012 a	- 216	906	286
200N+50P+50K		0.72 a	33 a	5.0 b	884 b	- 268	627	454
	14–15							
Control		0.27	15	5.2 c	697	18 a	299	301
185N+25P		0.41	20	3.3 c	623	-261 b	435	375
200N+50P+50K		0.28	12	6.3 a	695	75 a	219	335
	11–15							
Control		0.76 b	38 b	9.9	1396	-231	937	558
185N+25P		1.10 a	49 a	10.7	1635	-477	1340	661
200N+50P+50K		1.00 a	45 a	11.3	1579	-192	847	789

‡ PW = pulpwood; trees wit ha dbh of 4.6 to 6.5 inches, SP = superpulp; trees with a dbh of 6.6 to 8.5 inches, and CNS = chip-n = saw trees with a dbh > 8.5 inches.

* ft^3/ac = cubic feet per acre; 88 ft^3 = 1 cord of wood+bark, and 100 $ft^3 \approx 3$ tons.

growth increment means followed by a different letter are significantly different within an incremental period using Duncan's Multiple Range Procedure at the 5% alpha level.

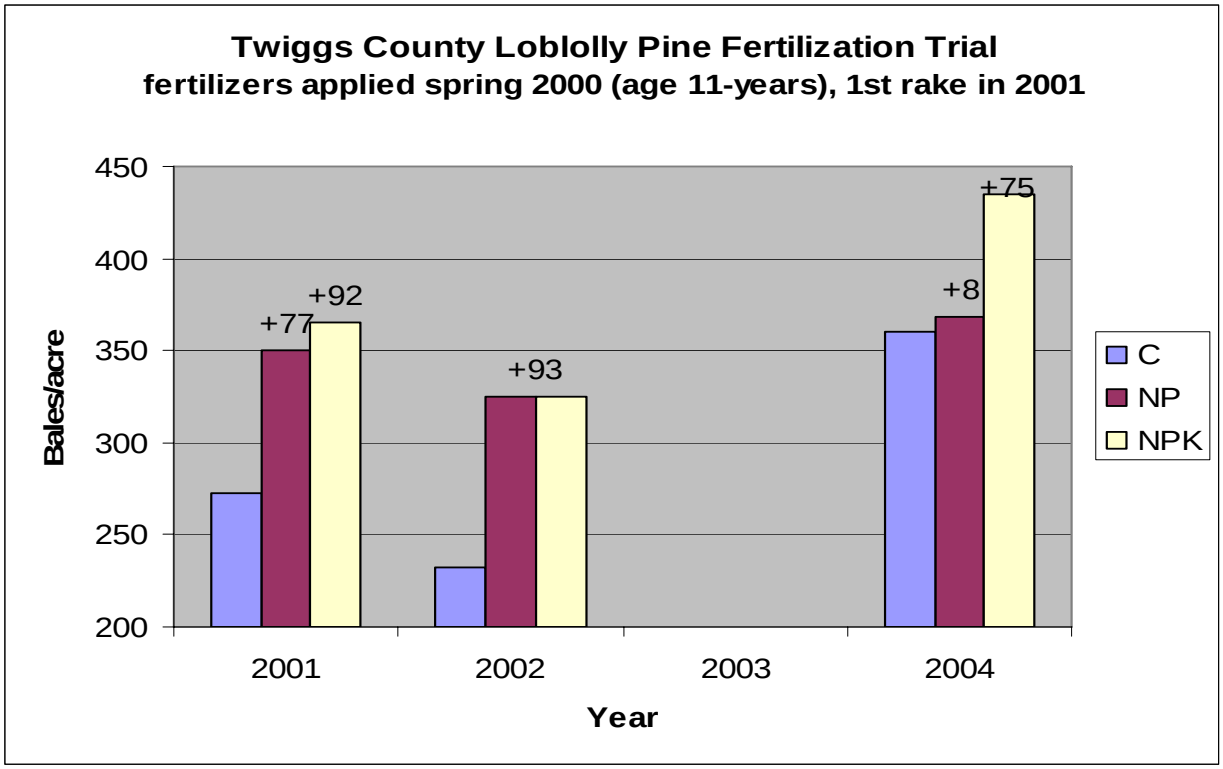

Figure 1. Pine straw production by fertilizer treatment in an unthinned cut-over site loblolly pine plantation in Twiggs County, Georgia (Norfolk and Orangeburg soils).

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