OLD-FIELD THINNED LOBLOLLY PINE PLANTATION FERTILIZATION WITH DIAMMONIUM PHOSPHATE PLUS UREA AND POULTRY LITTER – 4 YEAR GROWTH AND PRODUCT CLASS DISTRIBUTION RESULTS

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Abstract—A study area was installed in the Coastal Plain of South Carolina to determine the effects of diammonium phosphate (DAP) plus urea and poultry litter fertilization on growth, yield, diameter distributions, and product class distributions in an old-field (Norfolk soil) thinned loblolly pine (*Pinus taeda* L.) plantation. Treatments included: (1) control = no fertilization, (2) 125 DAP + 385 pounds urea per acre and (3) 7 tons per acre of broiler litter and were applied in the spring of 1998. The loblolly stand prior to thinning was highly stocked with an average of 750 trees per acre (TPA) and a basal area (BA) of 150 square feet per acre by the end of the tenth growing season. The stand was thinned back to 250 TPA and 50 square feet per acre basal area in January 1998. Mean d.b.h., basal area per acre and total heights were not significantly different between treatments prior to treatment and 4 years after treatment (YAT). Four YAT, the broiler litter treatment had a greater loblolly pine d.b.h. growth increment (2.5 inches) than the DAP+urea (1.9 inches) and the control (1.8 inches). Merchantable volumes for the control, DAP+urea, and broiler litter treatments were not significantly different 4 YAT. Chip and saw volume per acre growth increment (d.b.h. > 8.5 inches) for the broiler litter treatment (1,030 cubic feet per acre) was 42 percent greater than the control and 44 percent greater than the DAP+urea 4 YAT.

INTRODUCTION

South Carolina's forest and poultry industries are important to the State. Forest land application of poultry litter is a viable alternative for litter utilization in South Carolina and other Southern States. However, many nonindustrial private forest (NIPF) landowners question the benefit of poultry litter application in pine plantations compared to traditional inorganic fertilizer materials. The objectives of this study were to (1) determine old-field loblolly pine (*Pinus taeda* L.) growth response and (2) product class distribution changes as a function of a one-time poultry litter compared to a common operational diammonium phosphate (DAP), (18-46-0) plus urea (46-0-0) application and no fertilizer treatment after the stand was thinned.

METHODS

The study area was an old-field planted loblolly pine plantation located in Clarendon County, SC in the Atlantic Coastal Plain physiographic region. The soil was mapped as the Norfolk soil series (fine-loamy, Typic Kandiudults). The entire plantation was thinned at the end of the tenth growing season from 750 trees per acre (TPA) and 155 square feet per acre basal area to 250 TPA and 50 square feet per acre basal area in January 1998. The experimental design was complete block with three replications per treatment. The treatments were: (1) control = no fertilizer materials, (2) 125 pounds DAP plus 385 pounds urea per acre [200 N + 25 P per acre], and (3) 7 wet tons poultry litter per acre. The latter treatment level (table 1) gave a similar plant available nitrogen (N) level as the N in the DAP and urea. Nine internal permanent measurement plots (IPMP), (1/4 acre) were installed in the center of each the gross treated plot (1/2 acre). Forty feet of untreated buffer were maintained between all plots. All living trees in each IPMP were tagged, numbered, and measured for d.b.h (diameter tape) and total height (initially with a height pole and subsequently with a laser hypsometer) prior to treatment. Sampling was conducted in February 1998 to establish baseline soil (0-6 inches using 1-inch diameter soil probe at 10 random locations per plot) and foliar (3 dominant trees per plot, upper 1/3 crown, south side, first flush of previous year's growth) nutrient status. Post-treatment soil and foliage samples were collected during the winter on a biennial basis. The DAP and urea were applied by a granular spreader truck

Table 1—Poultry (stacked broiler litter) litter characteristics and application level from a 7 tons per acre application to an old-field thinned loblolly pine plantation at age 11-year-old in Clarendon County, SC

Component	Concentration	Application level
	percent	*pounds per acre*
Total-N	2.86	400.00
NH4-N	0.36	50.40
Organic-N	2.50	350.00
Available-N[a]	1.72	240.00
P_2O_5	2.64	370.00
K_2O	2.29	321.00
Ca	2.09	293.00
Mg	0.39	54.60
S	0.45	63.00
Cu	0.03	4.38
Zn	0.03	4.24

[a] Available-N = 60 percent of organic-N and ammonium-N is estimated to plant available when surface applied in the first growing season.

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Table 2—Soil (0-6 inches) nutrient status prior to treatment and 4 years post-treatment in the old-field thinned loblolly pine plantation in Clarendon County, SC

Treatment	pH	P	K	Ca	Mg	Cu	B
				ppm			
			1998				
Control	5.5	9	21	253	29	0.6	0.1
Fertilizer	5.8	12	20	281	30	0.5	0.1
Litter	5.8	2	24	348	44	0.5	0.1
			2002				
Control	5.8	3b [a]	16b	230b	25b	0.05b	0.05
Fertilizer	5.6	13ab	12b	201b	21b	0.05b	0.05
Litter	5.8	28a	38a	393a	55a	0.60a	0.20

[a] Nutrient treatment means within the same year followed by a different letter indicate significant differences at the $\alpha = 0.05$ level using Duncan's Multiple Range Test.

on April 28,1998 and the broiler litter was applied on June 8 and June 9, 1998 with a tractor and pull behind side port spreader. Both fertilizer materials were planned to be applied at the same time, but the broiler litter could not be applied until a tractor and spreader became available. All living trees were remeasured for d.b.h. and total height in March 2000 and March 2002. A volume equation for loblolly pine by Bailey and others (1985) was used to estimate merchantable volume (3-inch top inside bark, cubic feet) per acre, pulpwood volume (4.6 inches $\leq$ d.b.h $\geq$ 8.5 inches), and chip-and-saw volume (d.b.h. > 8.5 inches) per acre. Growth parameter means by treatment were compared statistically using Duncan's Multiple Range Test at the $\alpha = 0.05$ significance level.

RESULTS

Foliar N, P, K, Ca, Mg, B, and Cu nutrient status and soil extractable-P levels were at or above sufficiency for loblolly pine (Allen 1987, Pritchett and Comerford 1983, Wells and others 1973) in the study area prior to DAP+urea and poultry litter application (tables 2 and 3) except for soil extractable P in the poultry litter plots. There were no significant differences between treatment means for d.b.h, basal area, or total height during the 4 year study period (table 4). Trees per acre were initially not significantly different. The poultry litter treatment had significantly fewer TPA than the control 4 YAT. Four year mortality was 6.5 percent for the control, 11 percent for the DAP+urea, and 14.5 percent for the poultry litter treatment. Four year d.b.h. growth increment from the broiler litter treatment was greater (2.5 inches) than the control (1.8 inches) and DAP+urea (1.9 inches).

Table 3—Foliar nutrient status prior to treatment and 4 years post-treatment in the old-field thinned loblolly pine plantation in Clarendon County, SC

Treatment	N	P	K	Ca	Mg	Cu	B
			percent			*ppm*	
			1998				
Control	1.4	0.12	0.41	0.23	0.11	2.5	17
Fertilizer	1.3	0.12	0.40	0.24	0.13	2.7	16
Litter	1.4	0.12	0.41	0.31	0.14	3.2	21
			2002				
Control	1.3	0.12	0.43	0.22	0.14	3.5	13
Fertilizer	1.5	0.13	0.45	0.22	0.14	3.2	11
Litter	1.5	0.12	0.43	0.33	0.15	3.2	14

There were no significant differences in merchantable volume (3-inch top inside bark) per acre or chip-and-saw volume (d.b.h > 8.5 inches to a 6-inch top inside bark) per acre (table 5). The poultry litter treatment had significantly less pulpwood volume (d.b.h of 4.5 through 8.5 inches to a 3-inch top inside bark) 2 YAT (year 2000) than the control and DAP+urea treatments. This pulpwood trend of less pulpwood volume for the poultry litter compared to the control and DAP+urea continued 4 YAT but the treatments

Table 4—Pre-treatment (1998), 2 (2000), and 4 (2002) year post-treatment growth parameter means in an old-field thinned loblolly pine plantation in Clarendon County, SC

	Diameter			Basal area			Height		
Treatment	1998	2000	2002	1998	2000	2002	1998	2000	2002
	inches			*square feet per acre*			*feet*		
Control	6.2	7.2	8.0	56.4	75.7	87.9	32.2	36.7	41.2
Fertilizer	6.1	7.2	8.0	53.5	72.8	82.3	35.6	38.8	43.7
Poultry litter	6.2	7.6	8.7	54.5	73.0	90.8	32.6	37.2	41.8
P-value	0.846	0.338	0.077	0.843	0.844	0.395	0.170	0.643	0.611

Table 5—Pre-treatment (1998), 2 (2000), and 4 (2002) year post-treatment volume means in an old-field thinned loblolly pine plantation at age 11-years-old in Clarendon County, SC

	Merchantable volume			Pulpwood volume[a]			Chip and saw volume		
Treatment	1998	2000	2002	1998	2000	2002	1998	2000	2002
	cubic feet per acre								
Control	813	1250	1607	795	917a	717	14	269	738
Fertilizer	846	1283	1609	826	985a	727	15	243	731
Poultry litter	800	1225	1692	749	646b	435	41	474	1071
P-value	0.920	0.936	0.880	0.779	0.007	0.235	0.173	0.292	0.351

[a] Treatment means followed by a different letter indicate significant differences at the α = 0.05 level using Duncan's Multiple Range Test.

means were not significant. Chip-and-saw volume 4 year growth increment for the poultry litter treatment (1,030 cubic feet per acre) was 42 percent greater than the control (724 cubic feet per acre) and 44 percent greater than the DAP+urea (716 cubic feet per acre).

DISCUSSION

Trees per acre mortality differences over the 4 year study period may have occurred due to an annosum root disease [*Heterobasidion annosum* (Fr.) Bref.] problem on the edge of the poultry litter and DAP+urea plots in replications two and three. This problem appears to have dissipated 4 YAT. Whether the poultry litter and DAP+urea fertilization increased the annosum root disease spread, thereby increasing mortality over the control, is not known.

A common loblolly response to N+P fertilization using DAP+urea is approximately 60 cubic feet per acre per year volume increase lasting 5 to 8 years (NCSUFNC 1998). The negligible response to the DAP+urea treatment may have been due to at least three factors: (1) an application timing problem, (2) foliar nutrient status was sufficient, and (3) greater mortality (11 percent) compared to the control (6.5 percent). Kissel and others (2001) noted that ammonia volatilization losses can be substantial in closed canopy loblolly pine stands when air temperature and relative humidity are high. Twenty-five days lapsed between the time of DAP+urea treatment and the first substantial rain (> ½-inch) in the study area with temperatures and relative humidity that were higher than the historic average for the area. In contrast, a ¾-inch rain occurred 1 hour after the last poultry litter plot was treated on June 9, 1998. Another plausible explanation to the lack of response to DAP+urea fertilization is indicated by the soil extractable-P levels (table 2) and foliar N and P (table 3) concentrations being above the minimum guidelines (Allen 1987, Pritchett and Comerford 1983, Wells and others 1973) for a significant fertilization response to occur in the DAP+urea plots.

Statistically, there were few treatment mean differences 4 YAT; however there were two important trends that occurred. Mean d.b.h. 4-year growth increment for the poultry litter plots (2.5 inches) was 32 percent greater than the DAP+urea (1.9 inches) and 39 percent greater than the control (1.8 inches). Chip-and-saw (CNS) volume for the poultry litter treatment was over 300 cubic feet per acre greater than the control and DAP+urea 4 YAT. The 4 YAT pulpwood volume increment decrease for the poultry litter treatment was 236 cubic feet per acre less than the control and 215 cubic feet per acre DAP+urea 4 YAT (table 5). Therefore, while the merchantable volume for the poultry litter treatment was not significantly greater than the control, product class distribution changes were more dramatic in the poultry litter treatment than the control due to the 0.70 inch d.b.h. growth increase 4 YAT.

Economically, applying South Carolina third quarter 2002 stumpage prices (TMS 2002) of $14 per cord for pulpwood and $58 per cord for CNS (86 cubic feet per cord wood+bark), the poultry litter treatment volume per acre value ($793) was 30 percent greater than the control ($610) and DAP+urea ($611) treatment 4 YAT. Using a common South Carolina $10 per ton cost for the litter and application and the revenue gain of $193 per acre between the poultry litter and control, the internal rate of return $[(193/70)^{1/4} - 1]$ for the poultry litter treatment is 28.8 percent for the extra wood grown 4 YAT.

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