APPLICATION OF PELLETIZED POULTRY MANURE AT TIME OF PLANTING

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ABSTRACT

Field studies conducted in the Georgia Coastal Plain indicate that pelletized chicken litter applied at a 1 dry ton/acre rate (26.5 lb/acre P) can serve as a good P source for pine stand establishment. Pine seedling mortality was observed on a poorly drained, wet site associated with higher (3 ton/acre) treatment rates, perhaps because anaerobic conditions may lead to excessive ammonia build-up. Greenhouse studies indicated that poultry manure-primary paper pulp sludge mixtures have potential value as a slow-release nutrient source, but fresh mixtures of the two materials retain some of the adverse properties that lead to poor seedling survival in soils amended with fresh poultry manure. Pine survival and growth is improved by composting poultry-primary sludge mixtures before application. Over-application of fresh litter can result in excessive NO_3-N leaching below the root zone to groundwater.

Economic analysis indicates that pelletized chicken litter applied at a 1 ton/acre rate would cost \$24.10/acre. This compares favorably with the current DAP application cost of \$30.00/acre. Weed control measures currently used in intensive stand management would minimize the potential increase in weed populations from litter applications. Limitations on the use of poultry litter include 1) the limited number of acres that can receive applications per day due to time considerations for hauling and handling, 2) the difficulty of operating traditional spreader trucks on uneven and poorly prepared sites, and 3) the convenience of procurement and aerial application of DAP, which may offset cost savings of using poultry litter.

However, poultry litter can be used as an alternative to industrial-standard fertilization when: 1) transportation distances are small, 2) it can be applied during site preparation, and 3) accommodations for equipment access to the stand are not excessive.

BACKGROUND

Georgia's forest and poultry industries are two of the largest industries in the state, contributing an estimated 26 billion dollars to the annual economy and directly employing 175,000 workers (Georgia Forestry Commission 1995, Mauldin, Lacy, and Savage 1993). The use of poultry litter as fertilizer on cattle pasture or hay fields is a farming tradition. The continued heavy repeated application has led to elevated soil P levels. Federal and state regulators are implementing tougher nutrient management rules to control P build-up in the soil and prevent potential water pollution.

If pasture application is reduced, alternative uses for the litter need to be established. Various ideas have been proposed, including processing it into other products and burning it to generate electricity. Processing and burning could be years away and could become bogged down in legal battles. Application of poultry litter to forest land may be a promising nutrient utilization alternative due to vast wooded areas in proximity to areas of concentrated poultry production and the potential tree growth benefits from nutrients in litter. Also, Coastal Plain soils are often P-deficient and stand establishment requires P fertilization.

When addressing a litter application, however, it must be decided whether to consider a waste disposal problem or to attempt to meet nutrient requirements for pine (crop) growth. If the objective is to meet nutrient requirements, a nutrient management plan will maximize the economic advantages of nutrients and minimize undesirable offsite effects such as N or P movement in surface runoff or to groundwater.

To develop a nutrient management plan for pine fertilization, the following analyses are required: 1) a soil evaluation that may include a soil test to determine the supplemental needs of the crop, 2) a nutrient analysis of the manure which is to be spread, and 3) plant tissue analysis for mid-rotation and pine straw harvesting. Litter applications are then based on site condition, foliar analysis, and rotation/product management goals. If the soil test indicates <10-12 lbs/acre of P (Mehlich II extractable), then a manager normally applies 40-50 lbs of elemental P at planting (Jokela et al. 1991). A litter application will meet the P requirements and add N to the soil.

Chicken litter is equivalent to a 2.7 N, 2.8 P_2O_5, 2.2 K_2O fertilizer but has the advantages of being slow-release and supplies micronutrients (0.07 lb B, 0.53 lb Cu, 0.57 lb Zn/ton; Table 1). Factors affecting litter nutrient levels include 1) the number of broiler flocks grown on litter, 2) use of alum to control litter pH, 3) use of borate for darkling beetle control, 4) composted vs. non-composted litter, and 5) feed formulation. Studies have shown that only 50% of N applied as broiler litter is available for plant uptake during the first year (Gould, Guthrie, and Segars 1996). Thus 1 to 2 tons/acre of broiler litter will provide a good nutrient source to meet initial plant requirements at establishment without resulting in nutrient overload.

The potential use of poultry litter as a fertilizer source is limited by 1) low nutrient density, 2) low bulk density and 3) non-uniformity. Because of its low nutrient/bulk density, cost of transportation of this material is high. Previous work at the University of Georgia (W.C. Merka, University of Georgia Department of Poultry Science, unpublished data) has determined that a blend of fine fraction/middle fraction litter material produces a better pellet and requires much less energy than pellets made from the raw (whole) litter. By separating the litter fractions prior to pelleting, the pelletizing mill was also able to 1) decrease the material flow through a hammermill process which reduced energy costs and maintenance on the hammermill itself and 2) produce a uniform product with a nutrient (N, P_2O_5, K_2O) analysis of 4.6, 3.9, and 2.9%, respectively.

Since P is often a limiting nutrient in Coastal Plain forested pine stand establishment, it is of interest to investigate the use of chicken litter as a P source during stand establishment. Besides supplying the P requirement, the litter would supply other essential elements for pine growth and increase soil organic matter. Past attempts at broadcast application of chicken litter at stand establishment have resulted in aggravated weed problems due to increased soil fertility and improved soil conditions. Since current intensive pine silviculture prescriptions include weed control, a study was established in the Georgia Coastal Plain to evaluate graded levels of chicken litter as a nutrient source on P deficient sites.

FIELD STUDIES

Use of poultry litter as the P source at stand establishment in this region was evaluated by comparing the growth rate of loblolly (*Pinus taeda*) seedlings fertilized with poultry litter to seedlings fertilized with industrial-standard fertilizers presently used in intensive pine silviculture. Test plots were established in the Georgia Coastal Plain counties of Bulloch, McIntosh, and Tattnall on four soil types (Table 2). Extensive pine mortality was observed on the poorly drained Bladen soil site when litter was applied near the tree at planting (Bush, Merka, and Morris 1998). Pine survival rates for data presented in Table 2 were 97% for industrial-standard, 95% for broadcast application at 1 ton/acre, and 90.9% for the control. Pine mortality on Bladen soils appeared to be more severe in the wetter portions of the site. One might speculate that under the anaerobic conditions encountered on the wet site, ammonia build-up occurred to toxic levels at high litter application rates. However, surviving trees on these plots were the largest trees in the study area. Pine survival and growth on the well-drained, Ludowici, GA site (Chipley soils) and the Oliver, GA site (Albany and Blanton soils) were excellent (>95%).

Field study results from the Ludowici site indicate that broadcast application of pelletized chicken litter at a rate of 1 ton/acre produced significantly greater growth (tree height) and root collar diameter than did industrial-standard fertilization treatment or control (Table 2). Evaluation of the Ludowici site at the end of the second year (Table 2) showed that treatment-related differences carried through Year 2. Unexpectedly, there was no difference in growth between the control and industrial-standard fertilization treatment in this particular study.

Evaluation of plant tissue analysis from the Ludowici site revealed that chicken litter treatments elevated the foliar P levels and this increase was significant in the second-year post-plant. Although all treatments except B and Cu were in the sufficiency range, there was an increase in P foliage content with increasing chicken litter treatment level. Thus, chicken litter served as a P source. Additions of excessive N fertilizer may promote growth to the point that micronutrients such as B and Cu become deficient (Mills and Jones 1996).

An additional set of plots established on a site near Oliver, GA had wet soils (Albany soil series) and relatively well-drained soils (Blanton soil series). Survival was >95% on both soil types. Again the broadcast application of pelletized chicken litter at a 1 ton/acre rate produced greatest height vs. control and industrial-standard fertilization only on Albany Soil (Table 2). Plant tissue analysis conducted on 1-year foliar samples showed nutrients in sufficiency range and no significant differences in N, P, K, Mg, Mn, Fe, Al, B, Ca, or Cu.

In a second set of trials, pelletized chicken litter was applied to slash pine plots to evaluate broiler litter as a potential P source for pine regeneration. Pelletized chicken litter applied at the 1 and 2-ton rate produced growth comparable to the industrial-standard diammonium phosphate (DAP) application rate (125 lbs/acre) and greater than the untreated control 1 and 2 years after establishment (Table 3). The significant growth increase in the industrial-standard application plots vs. the untreated control plots was not observed in the second year. This may reflect lower sensitivity of height than ground-line diameter as a response variable. The 2-ton application rate did not give an additional growth response over the 1-ton litter rate. Addition of DAP at N rates equivalent to litter rates did not produce additional height growth over the litter rate. Pine survival and growth were excellent in all treatments.

First-year foliar tissue analysis showed significant response to P fertilization but the response was not significant at the end of the second year (Bush et al. 1999). No significant treatment-related effects were observed for foliar N, K, Cu and Zn at Years 1 or 2 (Bush et al. 1999). Boron levels were significantly lower in pines that received supplemental N fertilization. Boron deficiency has been observed in the Coastal Plain of the Southeast. In most plants, the average B content is 20 $mg \cdot kg^{-1}$ (ppm) on a dry-weight basis with 8-12 ppm considered the critical range for slash pine. Applications of N have induced B deficiency in plants when soil B levels were low; evidently the result of a dilution of B and its failure to move from older to developing meristematic tissues. Boron deficiency is expressed as an abnormal or retarded elongation of growing points and/or apical meristems. Young leaves are misshapen, wrinkled, thicker, and darker in color. Eventually, terminal growing points die (Mills and Jones 1996).

Weed control, like that in Table 5, is a critical component in stand establishment and required if litter is added. Auburn University studies (Wilhoit and Samuelson 1996) reported that litter applications of 2-8 tons/acre at pine establishment without weed control decreased height growth 1 and 2 years post-treatment. If weeds were controlled, there was significant growth response. Study results in Tables 2 and 3 show significant growth from application of 1 ton of poultry litter to loblolly and slash pine at planting with first-year weed control. Weed control during stand establishment may add \$40-\$93/acre (Table 5) but usually is cost effective.

In a pine regeneration study in the sand hill region of north Alabama, Minkara et al. (1995) compared NO_3-N concentrations in solution below the root zone receiving N-rich litter (5.7% N) at 1.82 ton/acre ± weed control with ammonium-N application (206 lb N/acre) and an untreated control. They found soil leachate concentrations below root zone (2 ft) exceeded the 10 ppm drinking water standard for the first 7 months after application. Ammonium-N application gave the greatest NO_3-N level, followed by the 1.8 ton/acre litter application, litter + weed control, and control. They concluded that nutrients supplied over the NO_3 and NH_4 assimilative capacity of newly planted seedlings and vegetation regrowth resulted in NO_3 leaching.

OTHER PINE STAND RELATED USES OF LITTER

Fertilization beginning at age 5 in intensive management can give a positive growth response. If foliar analysis shows that P or N is low (<0.09% or <1.0%, respectively), then a manager will often receive an economically viable growth response from fertilization. Mid-rotation aged trees responded favorably to high-rate poultry litter applications. Litter application of 4 tons of litter will meet the N requirements but will exceed P requirements (Table 4). Auburn University studies have shown that application of 8 ton/acre of litter produced a significant increase in DBH over the control. In subsequent demonstration plots, significant stem diameter growth and foliar nutrient responses resulted from poultry litter applications at 4.5 ton/acre and fertilizer treatments, but not from a lower poultry litter application rate (2.2 ton/acre). The nutrient content of the poultry litter treatment was considerably higher than that of the fertilizer treatment, indicating that a substantial portion of the nitrogen in the poultry litter was not immediately available for utilization by the trees. Since mid-rotation stands have an extensive evapotranspiration component in the hydrologic budget, it is unlikely that extensive NO_3-N movement below the root zone will occur from a 4-6 ton/acre application.

Samuelson et al. (1999) found that poultry litter applications of 2-4 ton/acre to 18-years old, recently-thinned loblolly pine stands resulted in increased foliar N and P levels and increased stem diameter growth 18 months after application. They concluded that limited litter applications of 2-4 ton/acre enhance tree growth in older forest plantations and offer an alternative disposal site to agronomic and pasture land. Poultry litter applications, however, are limited by difficulties in land application.

Pine straw maintenance fertilization provides another opportunity to apply poultry litter and receive an economic response. Foliar analysis with N levels <1.1% and P levels <0.10 generally indicate a potential for pine straw production increases following fertilization. Pine straw production (needle yield) can be increased 40-50% by fertilization. Application of 2-4 tons of litter every five years will meet nutrient requirements (Table 4); however, a split application of 1.5-2.0 tons of litter every other year could provide increased nutrient utilization. Use of pelletized litter would reduce woody debris and feathers that might downgrade collected pine straw and produce a more nutrient-dense fertilization product.

The use of poultry litter as an amendment toother waste products like pulp and paper sludge may provide another possible use of the poultry by-product. Primary sludge from pulp and paper production largely consists of organic fiber with varying amounts of inorganic fillers. Its high C and low N content can result in N deficiencies when used in land application programs. An alternative to direct application of primary sludge is to produce a nutritionally balanced and more easily handled product by combining these sludges with animal wastes having higher N contents, such as poultry litter. For instance, primary sludge with a C/N ratio of 100/1 can be combined with poultry litter with C/N ratios of 5/1 to produce a slow-release fertilizer with initial C/N ratios of 25/1. The addition of ash generated from the combustion of wood wastes can also be combined in the mixture for odor reduction and also as a means of improving overall nutritional value.

A greenhouse study (Bush, Merka, and Morris 1998) indicates that poultry manure-primary sludge mixtures have potential value as a slow-release nutrient source, but that fresh mixtures of the two materials retain some adverse properties that lead to poor seedling survival in soils amended with fresh poultry manure. This survival problem may be reduced or eliminated by composting poultry-primary sludge mixtures prior to application.

ECONOMIC ASSESSMENT

For poultry litter to be adopted as a nutrient source for pine stand establishment, it must produce growth increase greater than or equal to the industrial-standard fertilization practice of applying 125 lbs of DAP (18-46-0) and the cost of procuring, transporting and applying litter should be equal to or less than the cost of procuring and applying DAP.

At $190/ton for DAP (1999 bulk dealer price) and an aerial application cost of $0.10/lb, the total cost per acre for an industrial application rate would be $30.00/acre (Table 6). Assuming that application costs for chicken litter are similar to application costs for other forest-applied organic materials, application will cost approximately $3.60/ton and hauling costs for up to 50 miles would be $0.30/ton/mile. For a 25 mile haul distance this would cost $7.50/ton. (Personal communication. Roger James. 1999. Custom fertilizer applicator, Airgrowers, Inc., P.O.

Box 417, Homerville, GA 31634). These costs, plus \$5.00/ton material cost, total \$16.10. The costs compare favorably with costs for aerial application of DAP at \$30.00/acre (Table 6). Pelletizing litter to obtain a more uniform, nutrient-rich product would add approximately \$8.00/ton for a total cost of \$24.10.

An Auburn University analysis shows net economic return on investment (pulpwood price of \$12.50/cord assumed) if the litter is free. If a landowner has to pay \$10-\$20/ton for litter, then there is a net loss on investment (Personal communication. Mark Dubois. 1999. Extension forestry specialist, dubois@forestry.auburn.edu, Auburn, AL).

SUMMARY

Field studies conducted in the Georgia Coastal Plain indicated that pelletized chicken litter applied at a 1 ton/acre rate serves as a P source for pine stand establishment. Pine seedling mortality was observed on a poorly drained, wet site associated with higher treatment rates, perhaps because anaerobic conditions may lead to excessive ammonia build-up. Leaf tissue N levels do not increase with increased litter level.

A greenhouse study indicated that poultry manure-primary sludge mixtures have potential value as a slow-release nutrient source, but fresh mixtures of the two materials retain some of the adverse properties that lead to poor seedling survival in soils amended with fresh poultry manure. This survival problem may be reduced or eliminated by composting poultry-primary sludge mixtures before application.

If litter is applied at rates designed to meet plant nutritional requirements, then it serves as a slow-release fertilizer. Over-application of litter can result in excessive NO_3-N leaching below the root zone to groundwater.

Economic analysis indicates that pelletized chicken litter applied at a 1 ton/acre rate would cost \$24.10/acre. This compares favorably with the current DAP application cost of \$30.00/acre. Weed control measures currently used in intensive stand management would minimize the potential increase in weed populations from litter applications.

Limitations on the use of poultry litter include 1) the limited number of acres that can receive applications per day due to time considerations for hauling and handling, 2) the difficulty of operating traditional spreader trucks on uneven and poorly prepared sites, and 3) the convenience of procurement and aerial application of DAP, which may offset cost savings of using poultry litter.

Poultry litter can be used as an economical alternative to industrial-standard fertilization if the litter is applied during site preparation for stand establishment. Accommodations have to be made for equipment access to the stand.

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Table 1. Unprocessed broiler litter nutrient content analyzed by UGA Agricultural and Environmental Services Labs 1994-1997 (463 samples). Results reported on an as-received basis.

Nutrient	Level	Range	Lbs/acre[a]
	%		
N	2.70	0.03-5.74	54.0 (27 lbs N available)
P	1.24	0.01-3.78	24.8
K	1.86	0.09-5.18	37.2
Ca	1.94	0.60-5.70	38.8
	ppm		
B	37.80	0.5-951	0.07
Cu	266	0.25-1010	0.53
Zn	287	15-2030	0.57
Na	4683	1-10,200	9.36
Pb	3.93	<1.2-214	<0.01
Ni	9.32	<1.0-73	0.02
Cr	5.77	<1.0-293	0.01
Mo	4.64	<0.5-30.2	0.009

All elements except N were determined by dry ashing at 600C, followed by ICP analysis. N was determined by Kjeldahl digestion and ammonia titration.

[a] When applied at 1 ton/acre rate

Table 2. Summary of loblolly pine regeneration studies conducted at 3 sites representing 4 soil types. Pine growth responses were evaluated during the first and second winters following treatment. (See Bush, Merka, and Morris 1998.) Treatments received first-year weed control.

Site	Soil	Treatment	Height (ft)		Stem diameter at soil line (in)	
			Year 1[a]	Year 2	Year 1	Year 2
Bladen, GA (McIntosh Co.)	Bladen[1]	Control	2.98A	--	0.76A B	--
		Broadcast (1 ton/acre)	3.03A	--	0.82A	--
		Industrial standard	2.94A	--	0.72 B	--
Ludowici, GA (Tattnall Co.)	Chipley[2]	Control	2.57 B	5.29 B	0.86 B	1.68 B
		Broadcast (1 ton/acre)	2.99A	5.81A	0.94A	1.94A
		Industrial standard	2.47 B	5.24 B	0.82 B	1.68 B
Oliver, GA (Bulloch Co.)	Albany[3]	Control	3.26 B	--	0.86A	--
		Broadcast (1 ton/acre)	3.56A	--	0.99 B	--
		Industrial standard	3.08 B	--	0.90 B	--
Oliver, GA (Bulloch Co.)	Blanton[4]	Control	2.96A	--	0.87 B	--
		Broadcast (1 ton/acre)	3.10A	--	0.96A	--
		Industrial standard	3.08A	--	0.90A B	--

[1]Bladen series soils are very deep, poorly drained, slowly permeable soils that formed in thick beds of acid clayey sediments on fluvial or marine terraces. Slopes range from 0 to 2%. Mean annual precipitation is ~50 inches and mean annual temperature is ~69F.
[2]Chipley series soils are very deep, moderately well drained to somewhat poorly drained, rapidly permeable soils that formed in thick deposits of sandy marine sediments. They are on lower Coastal Plain uplands. Slopes range from 0 to 2%.
[3]The Albany series consists of very deep, somewhat poorly drained soils that formed in Coastal Plain deposits of sandy material underlain by loamy sediments. Permeability is rapid in the thick, sandy surface horizon and moderate to moderately slow in the loamy subsoil.
[4]The Blanton series consists of deep, moderately well drained, very strongly acid soils of the Coastal Plain (slopes 0 to 5%). The soils are low in fertility and contain little organic matter;
[a]Means within a column and soil type followed by the same letter are not significantly different at the 5% level by Duncan's Multiple Range Analysis.

Table 3. Evaluation of 1 and 2-year slash pine growth. Plots received first-year weed control.

Treatment	Height (ft)		Root collar diameter (in)
	Year 1[a]	Year 2	Year 1
1 Control (no litter or industrial-standard fertilizer)	4.28 B	6.66 B	1.68 B
2 1 ton litter/acre (80 lbs N/acre, 26 lbs P/acre, 33 lbs K/acre)	4.87A	7.91A	1.82A
3 2 tons litter/acre	4.75A	7.24A B	1.78A
4 Industrial-standard fertilization rate (125 lbs DAP/acre)	4.70A	7.12A B	1.79A

Soil type: Fuquay; Pretreatment soil test: pH = 5.2, P = 7 (low), K = 47 (low), Ca = 363 (adequate), Mg = 49 (low); [a] Means within column followed by same letter are not significantly different at 0.05 level of significance as determined by Duncan's Multiple Range Analysis.

Table 4. Poultry litter nutrient requirements and application rates for a nutrient management plan.

Litter	Nutrient content (lbs/ton)	Newly planted pines: Recommended nutrient requirement[a] (lbs/acre)	Newly planted pines: Litter application rate (ton/acre) Raw[b]	Newly planted pines: Litter application rate (ton/acre) Pelleted[c]	Mid-rotation: Recommended nutrient requirement[a] (lbs/acre)	Mid-rotation: Litter application rate (ton/acre) Raw	Mid-rotation: Litter application rate (ton/acre) Pelleted	Pine straw raking: Recommended nutrient requirement[a] (lbs/acre)	Pine straw raking: Litter application rate (ton/acre) Raw	Pine straw raking: Litter application rate (ton/acre) Pelleted
N	54	<50	1-2	1	150-200	4	3	175-200	4	2-3
P	28	20-50	1-2	1	25	1	1	50	2	2
K	37.5	–	–		–	–		50	1-2	1-2

[a]Source: Moorhead, 1998; [b]Raw = broiler litter straight from the chicken house; [c]Pelleted = screened litter run through a pelletizing process.

Table 5: Useful herbicides for weed control during pine establishment. These herbicides can be applied over-the-top. For loblolly pine stands, add a 0.25% non-ionic surfactant. These are usually applied in March through April. Since the triazine herbicides are soil-active, the application rates are site and soil-specific.. See herbicide label for rates.

Trees	Herbicide	Rates		Cost/acre[a]
Loblolly and slash pine	Oust®	2 oz/acre		$27.71
	Arsenal®	4-6 oz/acre		$40.00-$60.00
			Application	$5.50
				$73.21-$93.21
Loblolly and slash pine	Oust®	2 oz/acre		$27.71
	Velpar®	4-6 pts/acre		$16.50-$24.75
			Application	$5.50
				$49.71-$57.96
Old fields: Loblolly and slash pine	Oust®	2-3 oz/acre		$27.71-$41.56
	AAtrex 4L®	4-8 pts/acre		$6.95-$13.90
			Application	$5.50
				$40.16-$60.96

[a]Chemical prices are per local agricultural chemical dealer (Rowland Chemical Co., 379 Oak St., Athens, GA 30601, 1999). Costs may be lower if large acreages are treated or large-volume applicator concentrates are available. Application costs of $5.50/acre are from Givan and Westberry, 1998. Ground application may be a little higher and aerial, a little lower. Use of trade names is for the reader's information and convenience and does not constitute endorsement or approval by the U.S. Department of Agriculture, University of Georgia, nor the Georgia Forestry Commission to the exclusion of any other suitable product.

Table 6. Cost breakdown for poultry litter application[a]

Item	Cost
Litter	$5.00/ton[a]
Transportation	
<10 miles (included in spreading cost) 25 miles ($.30/ton/mile)	$7.50/ton[a]
Spreading	$3.60/ton[a]
Pelletizing	$8.00/ton[b]
TOTAL FOR LITTER APPLICATION	$24.10/ton
DAP APPLICATION	$30.00/acre

[a]Source: Personal communication. Roger James. 1999. Custom fertilizer applicator, Airgrowers, Inc., P.O. Box 417, Homerville, GA 31634;
[b]Source: Personal communication. James Tatum. 1999. Mill owner, Glennville Mills, Glennville, GA 30427.