Poultry Litter Application Recommendations in Pine Plantations

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Introduction

Forest fertilization in the southeastern U.S. has increased greatly since the 1960's. In 1998, about one million acres of loblolly pine plantations were fertilized with commercial fertilizers (NCSUFNC 1999), usually diammonium phosphate (DAP; 18-46-0), urea (46-0-0), or triple super phosphate (TSP; 0-46-0). Currently, most pine plantation fertilization is on forest industry land. Loblolly pine is considered to be the southern pine species which is most responsive to fertilization and other cultural practices. Slash, longleaf pine, and other southern pine stands are also fertilized but not to the extent that loblolly pine plantations are fertilized. Rates of return from fertilization typically average 8-12%, but can be as high as 25-30% depending on fertilizer cost, extra wood grown, and product class values. Optimal use of any fertilizer material requires that some diagnostic tools are used. These tools include soil and foliage analysis, leaf area index (LAI) estimation, soil classification/grouping, visual symptoms, growth and yield modeling, and stand fertilizer trials (Jokela et al. 1991, Dickens 1999).

Generally there are three fertilization recommendation “windows” in pine plantations:

1. **at planting or early post-planting** to correct a nutrient deficiency (largely P limitations or specific micronutrients such as boron or copper),

2. **at canopy closure, age 5-8 years-old** (usually N+P), and

3. **after a 1st or 2nd thinning** in semi-mature stands (N, P, sometimes K, and micronutrients) or several years following thinning in semi-mature stands (N, P, sometimes K, and micronutrients).

Site-specific conditions determine the type and rate of fertilization within each of the above windows. For example, to correct a nutrient deficiency such as P in poorly to very poorly drained Atlantic Coast Flatwoods soils, a single application of phosphorus such as TSP @ 200-250 lbs/acre is often applied at planting (Jokela et al. 1991). In another case, nitrogen (N) plus phosphorus (P) such as DAP @ 125-250 lbs/acre is the general choice at planting if competing vegetation is controlled by herbicide application; however, this fertilization is not recommended if competing vegetation is not controlled. In the latter case, competing vegetation should be controlled pre- and post-planting during which the nutrient demands of pine seedlings/saplings are relatively low. In older loblolly and slash pine plantations that have reached canopy closure (after five- to eight-years-old) or after a thinning, diammonium phosphate and urea (@ 125-200 lbs DAP and 300-380 lbs urea/acre) are commonly applied in loblolly and slash pine stands.

Fertilization to enhance pine straw production in unthinned and thinned stands is recommended when raking occurs annually or more frequently then two to three times in the life of a stand (N, P, sometimes K, Mg, S, and micronutrients). Pine plantations should be fertilized every four to eight years to replace the nutrients removed when the straw (fresh brown needles or the forest floor litter layer) is raked and taken from the site.
BENEFITS OF POULTRY LITTER APPLICATION TO FOREST LAND

The non-industrial private forest landowner (NIPFL) sector has become increasingly interested in using commercial and other fertilizer materials such as poultry litter to fertilize stands. Approximately two-thirds of South Carolina and Georgia are forested, two-thirds of the forest land in these two states are owned by non-industrial private forest landowners. Both states are large poultry producers.

There are several advantages to forest land application of poultry litter.

(1) An abundance of forest land to apply poultry litter

(2) A year-around window to apply poultry litter

(2) Forest soils are generally low in plant available phosphorus (P).

(3) Pine stand wood volume and straw production response to a single application of poultry litter can be significant and relatively long lived (four to ten years)

(4) The addition of macro-nutrients other than N and P and micro-nutrients (especially Cu and Zn)

(5) Adding organic matter to the site (tons/acre)

(6) Increasing soil moisture holding capacity.

Limitations of Poultry Litter Application to Forest Land

There are some limitations to the use of poultry litter to fertilize forest lands.

(1) Access, turning radius, stump height, and rutting depth

(2) Excessive slope (>8 to 12 percent)

(3) Application levels to achieve nitrogen per acre goals are typically in tons/acre.

(4) Hauling distance (Bush et al. 1999)

(5) Labor and time constraints

(6) Spreader availability

Forest landowners and poultry producers need to check all aspects of application to make sure forest land application of poultry litter is feasible. Table 1 provides a checklist for landowner, stand, litter, and equipment needs.
Table 1. A Checklist for Pine Plantation Poultry Litter Application

<table>
<thead>
<tr>
<th>Factor</th>
<th>Check</th>
<th>satisfied/unsatisfied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interested landowners</td>
<td>Distance to sensitive areas acceptable (churches, neighborhoods, etc.)</td>
<td></td>
</tr>
<tr>
<td>Suitable stand(s):</td>
<td>Access (row thinned, &gt;10 to 12' between row if unthinned), turn-around areas</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Percent slope &lt; 8%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% hardwoods (&lt;10% of stand basal area)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% fusiform rust stem canker incidence (&lt;25% for slash and &lt;30% for loblolly)</td>
<td></td>
</tr>
<tr>
<td>Litter availability</td>
<td>Amount (tons) and distance (miles) from stands</td>
<td></td>
</tr>
<tr>
<td>Equipment availability</td>
<td>Old-field sites: spreader, tractor (minimum HP is 50 to 75), cut-over sites: skidder + spreader box, at house: front end loader</td>
<td></td>
</tr>
<tr>
<td>N or P per acre stand needs</td>
<td>Species, age, stocking, soils (refer to Table 2)</td>
<td></td>
</tr>
<tr>
<td>Tons per acre application level</td>
<td>Based on Table 2 and examples following</td>
<td></td>
</tr>
<tr>
<td>Calibration area</td>
<td>Near litter source; open fields</td>
<td></td>
</tr>
</tbody>
</table>

If any of the above criteria are not satisfied then other options/sites may need to be pursued.
Worksheet for Determining the Recommended Application Levels of Poultry Litter

A. Fill in the following information about stand characteristics and nutrient needs:

Species: 

Age: 

% Hardwood basal area 

(if > 10% of stand basal area then control hardwoods first if optimizing pine production is a primary goal)

% Fusiform rust stem canker incidence 

(if >25% for slash or 30% for loblolly then split apply litter or delay application until after thinning)

P needs = pre- to early post-planting (Table 2)

N needs = canopy closure, pine straw prodn, after thinning (Table 2)
A. **At planting to early post-planting tons/acre calculation based on P needs:**

Assume stand needs 50 lbs elemental-P/acre (114 lbs P\textsubscript{2}O\textsubscript{5}). Using Table 3 as the litter analysis example, assume 1.24% elemental-P/ton (2.83% P\textsubscript{2}O\textsubscript{5}) “as sampled” in the litter or 0.0124 fraction of litter is elemental-P.

**Step 1:** determine target N or P needs/acre
- Goal = 50 lbs elemental-P/acre for at planting (114 lbs P\textsubscript{2}O\textsubscript{5})

**Step 2:** determine target nutrient (in this case P) lbs/ton in litter
- In litter = 2000 lbs x 0.0124 = 24.8 lbs elemental-P per ton litter (56.5 lbs P\textsubscript{2}O\textsubscript{5}/ton)

**Step 3:** divide target P needs/acre (lbs/acre) by elemental-P in litter (lbs P/ton litter)
- 50 lbs P/acre ÷ 24.8 lbs P/ton litter = 2 tons/acre (as P\textsubscript{2}O\textsubscript{5} 114 ÷ 56.5 = 2 tons/ac)

Actual analysis values: _____x_____ percent elemental-P (or P\textsubscript{2}O\textsubscript{5}) in litter ÷ 100

_____y_____ lbs elemental-P/ton (or P\textsubscript{2}O\textsubscript{5}) litter = 2000 * x

or _____50_____ Target elemental-P application level

_____114_____ Target P\textsubscript{2}O\textsubscript{5} application level

Calculation for tons/acre of litter = 50 ÷ y = tons/acre based on elemental-P needs

or Calculation for tons/acre of litter = 114 ÷ y = tons/acre based on P\textsubscript{2}O\textsubscript{5} needs.

**Generally at planting tons/acre for most broiler, breeder, and layer litters based on P needs = 1 to 2 tons/acre.**
B. **At canopy closure or after thinning tons/acre calculation based on total-N calculation:**

Assume loblolly or slash pine stand needs 200 lbs total-N/acre. Using Table 3 as the litter analysis example; total-N is 2.7%

Step 1: determine target N or P needs/acre  
Goal = 200 lbs total-N/acre for application at canopy closure or after thinning

Step 2: determine target nutrient (in this case total-N) lbs/ton in litter  
In litter = 2000 lbs x 0.0270 = 54.0 lbs N per ton litter

Step 3: divide target N needs/acre (lbs/acre) by total-N in litter (lbs total-N/ton litter)  
200 lbs N/acre ÷ 54 lbs N/ton litter = 3.7 tons/acre

Actual values: _____x_____ percent total-N in litter ÷ 100  
_____y_____ lbs total-N/ton litter = 2000 * x  
_____200___ Target total-N application level

Calculation for tons/acre of litter = 200 ÷ y = tons/acre based on total-N calculation. The 3.7 tons/acre poultry litter application level would also have 92 lbs total-P (210 lbs P₂O₅), 138 lbs total-K (166 lbs K₂O), 144 lbs Ca, 0.28 lbs B, 2 lbs Cu, & 2 lbs Zn/ac.

**Generally canopy closure or after thinning application levels based on total-N using most broiler, breeder, and layer litters are:**

(a) in loblolly and slash pine stands = 3 to 5 tons/acre

(b) in longleaf stands (dbh dependant) = 1 to 2.5 tons/acre
C. **At canopy closure or after thinning tons/acre calculation based on plant available-N (PAN) calculation:**

Assume landowner would like to apply 200 lbs PAN/acre in a loblolly or slash pine stand. Using Table 3 as the litter analysis example; PAN = 50% of organic-N + 60% of NH₄-N + 100% of NO₃-N or 60% of total-N in the first year.

We will assume 60% of total-N is plant available-N (PAN) as an estimate in this case.

Step 1: determine target N or P needs/acre

Goal = 200 lbs PAN/acre for application at canopy closure or after thinning

Step 2: determine target nutrient (in this case PAN) lbs/ton in litter

In litter = 2000 lbs/ton x (0.0270 x0.60) = 32.4 lbs PAN per ton litter

Step 3: divide target N needs/acre (lbs/acre) by PAN lbs/ton estimate in litter

200 lbs PAN/acre ÷ 32.4 lbs PAN/ton litter estimate = 6.2 tons/acre

Actual values: _____ x _____ percent total-N in litter ÷ 100 * 0.60

_____ y _____ estimated lbs PAN/ton litter = 2000 * x

_____ 200 _____ Target PAN application level

Calculation for tons/acre of litter = 200 ÷ y = tons/acre based on PAN calculation.

**Generally canopy closure or after thinning application levels based on PAN using most broiler, breeder, and layer litters are:**

(a) in loblolly and slash pine stands = 5 to 7.5 tons/acre

(b) in longleaf stands (dbh dependant) = 2 to 3.5 tons/acre
Applications Levels in Southern Pine Plantations

Loblolly pine is the most nutrient demanding of our Atlantic and Gulf Coastal Plain southern pines, slash pine is intermediate in nutrient demands, and longleaf is the least nutrient demanding. The poultry litter application level should be specifically designed to meet landowner objectives, and species, age, stocking, and site specifications. For example, too much nitrogen can make young longleaf pines top-heavy due to too much foliage produced in a short period of time. The stem cannot support the extra weight and 15-20% of a stand can lean over and never recover (Dickens 2000).

Nitrogen and P recommendations in Table 2 are derived from a combination of numerous commercial fertilizer poultry litter trials in loblolly, longleaf, and slash pine plantations and are currently “best estimates”. The values in the table are a compromise between environmental issues and silvicultural production optimums. Several poultry litter application projects are underway or are being proposed in the southeastern U.S. As information is collected and summarized, the N and P application recommendations will be refined. Before beginning a fertilization program, it is advisable to check with the Cooperative Extension Service and/or the State Forestry Commission for the current N and P recommendations particular to the state and pine stand factors. Current annual poultry litter application “best estimates” in pine plantations should attempt to achieve approximately 30-50 lbs N/acre until age 5-years-old and 50 to 75 lbs N/acre after age 5 for loblolly and slash pine. Excellent weed control must be achieved prior to applying poultry litter in young stands that have not reached canopy closure. Initial poultry litter applications in pine plantations will typically be based on P (at planting) or N needs (after canopy closure).

Tons per acre rate determination may be based on total-N (organic-N + ammonium/ammonia-N + nitrate/nitrite-N) or PAN (plant available N) in the poultry litter. Total-N is much easier to quantify analytically but not all of total-N may be plant available in the first or second growing season. Total Kjeldahl N (TKN) is a good estimate of total-N where nitrate/nitrite-N is negligible.

A second, frequently used basis for determining the N rate for crop and pastureland is plant available-N or PAN. Generally 100% of nitrate/nitrite-N, 50 to 60% of ammonium/ammonia-N (when surface applied), and 40 to 50% of organic-N (total Kjeldahl-N minus ammonium-N) are estimated to be plant available in the first growing season. Ammonium can be converted to nitrate or transformed to ammonia. Ammonia is a gas that can be readily lost to the atmosphere. Ammonia losses are dependent on temperature, moisture, relative humidity, wind speed, and micro-environment pH. If a 1/4 inch or more rain occurs within 24 hours of surface applied poultry litter application, ammonia-N losses can be minimal. Often PAN in most poultry litters is estimated to be 50% to 60% of total-N when surface applied. Poultry litter incorporation with disking should be done within 24 to 48 hours of application to minimize N losses. Disking to incorporate litter is limited to intensively prepared cut-over, old field, and pasture sites months prior to planting and is not recommended in established pine stands.
Table 2. Nitrogen (N) and phosphorus (P) fertilization recommendations for single or repeat applications every 4 to 5 years to southern pine species in well stocked stands (broadcast and surface applied).

<table>
<thead>
<tr>
<th>Species</th>
<th>Age(yrs) / size</th>
<th>N recommendation</th>
<th>P recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loblolly1</td>
<td>1 to 4</td>
<td>40 to 50</td>
<td>25 to 50</td>
</tr>
<tr>
<td></td>
<td>5 to 10</td>
<td>80 to 150</td>
<td>25 to 50</td>
</tr>
<tr>
<td></td>
<td>11 to 35</td>
<td>200</td>
<td>25 to 50</td>
</tr>
<tr>
<td>Slash2</td>
<td>1 to 4</td>
<td>40 to 50</td>
<td>25 to 50</td>
</tr>
<tr>
<td></td>
<td>5 to 10</td>
<td>70 to 110</td>
<td>25 to 50</td>
</tr>
<tr>
<td></td>
<td>11 to 35</td>
<td>150 to 200</td>
<td>25 to 50</td>
</tr>
<tr>
<td>Longleaf</td>
<td>establishment</td>
<td>not recommended</td>
<td></td>
</tr>
<tr>
<td></td>
<td>mean dbh &lt; 6.0&quot;</td>
<td>50 to 75</td>
<td>25 to 50</td>
</tr>
<tr>
<td></td>
<td>mean dbh &gt; 6.0&quot;</td>
<td>75 to 125</td>
<td>25 to 50</td>
</tr>
</tbody>
</table>

1 fusiform stem canker incidence < 30% and hardwood basal area/acre < 10 ft²
2 fusiform stem canker incidence < 25% and hardwood basal area/acre < 10 ft²

Table 3 lists the average nutrient content of unprocessed broiler litter that was analyzed by the University of Georgia’s Agricultural and Environmental Services Laboratory during 1994-97. These results were used in examples A, B, and C to estimate the tons/acre of broiler litter needed to achieve 50 lbs elemental-P/acre, 200 lbs total-N/acre, or 200 lbs PAN/acre, respectively, in loblolly and slash pine stands. Table 4 lists mean nutrient concentrations for samples received in 2000-2001 at the UGA Agricultural and Environmental Services laboratory.

Fertilization with poultry litter to enhance pine straw production can be made every four to eight years. The N and P fertilizer recommendations listed in Table 2 should be used to determine the poultry litter application tons/acre needs. Fertilization using poultry litter, other organic fertilizer materials, and commercial fertilizers will generally increase pine straw production by 40-50% starting 15 to 24 months after application and last 3 to 5 years (Dickens 2000). Wood volume should also increase, generally by 15 to 40% during this same period (Dickens and Miller 1998, Dickens 2000, Dickens et al. 2002). Refer to Fertilization to Enhance Pine Straw Production (Dickens et al. 2003) on www.bugwood.org for more specific fertilization recommendations for pine straw production.
Table 3. Unprocessed broiler litter nutrient content analyzed by UGA Agricultural and Environmental Services Labs 1994-1997 (463 samples). Results reported on an “as sampled” basis.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Concentration (%)</th>
<th>lbs/ton (as sampled)</th>
</tr>
</thead>
<tbody>
<tr>
<td>total-N</td>
<td>2.70</td>
<td>54</td>
</tr>
<tr>
<td>organic-N</td>
<td>1.50</td>
<td>30</td>
</tr>
<tr>
<td>NH₄-N</td>
<td>1.18</td>
<td>23.6</td>
</tr>
<tr>
<td>NO₃-N</td>
<td>0.02</td>
<td>0.4</td>
</tr>
<tr>
<td>total-P</td>
<td>1.24</td>
<td>24.8</td>
</tr>
<tr>
<td>total-K</td>
<td>1.86</td>
<td>37.2</td>
</tr>
<tr>
<td>total-Ca</td>
<td>1.94</td>
<td>38.8</td>
</tr>
<tr>
<td>B</td>
<td>0.00378</td>
<td>0.076</td>
</tr>
<tr>
<td>Cu</td>
<td>0.0266</td>
<td>0.53</td>
</tr>
<tr>
<td>Zn</td>
<td>0.0287</td>
<td>0.57</td>
</tr>
</tbody>
</table>

Precautions

Special care should be taken in a pine stand in loblolly, longleaf, and slash pine’s northern range where ice and snow are common and can weigh down crowns or where stem fusiform cankers are relatively high (> 25-30%). A forest landowner does not want to lose 15-20% of their stand due to producing top-heavy trees that lean over and never recover. This has happened in more than one case in young longleaf stands with overapplication of N from organic and inorganic fertilizers (Dickens 2000). Fertilization using poultry litter is not recommended in areas of high risk for pitch canker and annosus root rot.

For forest land application of poultry litter, the recommended water table depth at time of application should be greater than 20 inches for sandy soils and 30 inches for loamy to clayey soils. Crop tree growth can be reduced by damage to perennial tree root systems and by soil compaction when applications are made during a higher water table periods. Soil compaction may also produce an anaerobic soil condition that can increase ammonium-N levels and reduce seedling survival. Heavy equipment should not be used to apply poultry litter at a site where water can be squeezed out of a handful of soil.
Table 4: Results of poultry litter analysis at UGA Agricultural and Environmental Services Laboratory. In the absence of site specific data, these values provide a good basis for nutrient management planning. Values are in percent followed by one standard deviation ( ). All values are on an “as received” basis (not dry weight basis).

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Fresh Broiler Litter</th>
<th>Stockpiled Broiler Litter</th>
<th>Composted Broiler Litter</th>
<th>Fresh Layer Litter</th>
<th>Fresh Broiler Breeder Litter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N)</td>
<td>3.15% (0.60)</td>
<td>2.78% (0.86)</td>
<td>2.80% (0.98)</td>
<td>2.26% (0.83)</td>
<td>2.12% (0.79)</td>
</tr>
<tr>
<td>Phosphate (P₂O₅)</td>
<td>2.77 (0.81)</td>
<td>2.84 (0.94)</td>
<td>3.00 (1.00)</td>
<td>3.16 (1.34)</td>
<td>3.14 (1.17)</td>
</tr>
<tr>
<td>Potassium (K₂O)</td>
<td>2.33 (0.62)</td>
<td>2.29 (0.69)</td>
<td>2.30 (0.83)</td>
<td>2.05 (0.81)</td>
<td>1.93 (0.63)</td>
</tr>
<tr>
<td>Calcium (Ca)</td>
<td>1.80 (0.84)</td>
<td>1.92 (0.96)</td>
<td>2.05 (1.21)</td>
<td>6.43 (3.38)</td>
<td>6.38 (2.71)</td>
</tr>
<tr>
<td>Magnesium (Mg)</td>
<td>0.39 (0.12)</td>
<td>0.40 (0.12)</td>
<td>0.40 (0.24)</td>
<td>0.37 (0.15)</td>
<td>0.35 (0.14)</td>
</tr>
<tr>
<td>Sulfur (S)</td>
<td>0.42 (0.16)</td>
<td>0.39 (0.13)</td>
<td>0.40 (0.15)</td>
<td>0.36 (0.15)</td>
<td>0.38 (0.18)</td>
</tr>
<tr>
<td>Boron (B)</td>
<td>0.003 (0.003)</td>
<td>0.003 (0.001)</td>
<td>0.003 (0.01)</td>
<td>0.021 (0.001)</td>
<td>0.002 (0.001)</td>
</tr>
<tr>
<td>Copper (Cu)</td>
<td>0.034 (0.018)</td>
<td>0.033 (0.019)</td>
<td>0.029 (0.016)</td>
<td>0.011 (0.013)</td>
<td>0.011 (0.017)</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>0.027 (0.008)</td>
<td>0.028 (0.010)</td>
<td>0.026 (0.008)</td>
<td>0.029 (0.014)</td>
<td>0.028 (0.010)</td>
</tr>
<tr>
<td># of Samples</td>
<td>3113</td>
<td>309</td>
<td>85</td>
<td>180</td>
<td>418</td>
</tr>
</tbody>
</table>

From: D. Kissel, Annual Poultry Litter Test Summary July 2000- July 2002, UGA Agricultural And Environmental Services Laboratory, 2400 College Station Road, Athens, GA 30602.

Preliminary Research Findings

At Planting

Bush et al. (1998) studied loblolly pine survival after two growing seasons in the lower Coastal Plain of Georgia on Bladen, Chipley, Albany, and Blanton soils. Weeds were controlled in all plots during the first year. Survival was 97% in the 125 lbs DAP/acre plots, 95% in the 1 ton broadcast pelletized (4.5% total-N, 4% P₂O₅, 3% K₂O) poultry litter/acre plots, and 91% for the controls (herbicide only). In years one and two on the Chipley soil
mean total height and groundline diameter of the trees in the poultry litter + herbicide plots were significantly greater than the mean total height and groundline diameter of DAP + herbicide treated trees and the controls (Table 5). The poultry litter + herbicide pine groundline diameter was significantly greater than the control in year one on the Blanton and Albany soils, both of which are loamy, Grossarenic Paleudults.

Table 5. Summary of loblolly pine regeneration studies at three sites representing four soil types. Pine growth responses were evaluated during the first and second winters following treatment. Treatments received first year weed control (Bush et al. 1998).

<table>
<thead>
<tr>
<th>Site</th>
<th>Soil</th>
<th>Treatment</th>
<th>Year 1a ht (ft)</th>
<th>Year 2 ht (ft)</th>
<th>Year 1 gld1 (in)</th>
<th>Year 2 gld (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladen</td>
<td>Bladen</td>
<td>Control</td>
<td>2.98a</td>
<td>--</td>
<td>0.76ab</td>
<td>--</td>
</tr>
<tr>
<td>GA</td>
<td></td>
<td>Poultry L2</td>
<td>3.03a</td>
<td>--</td>
<td>0.82a</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DAP3</td>
<td>2.94a</td>
<td>--</td>
<td>0.72 b</td>
<td>--</td>
</tr>
<tr>
<td>Ludowici</td>
<td>Chipley</td>
<td>Control</td>
<td>2.57 b</td>
<td>5.29 b</td>
<td>0.86 b</td>
<td>1.68 b</td>
</tr>
<tr>
<td>GA</td>
<td></td>
<td>Poultry L</td>
<td>2.99a</td>
<td>5.81a</td>
<td>0.94a</td>
<td>1.94a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DAP</td>
<td>2.47 b</td>
<td>5.24 b</td>
<td>0.82 b</td>
<td>1.68 b</td>
</tr>
<tr>
<td>Oliver</td>
<td>Albany</td>
<td>Control</td>
<td>3.26 b</td>
<td>--</td>
<td>0.86 b</td>
<td>--</td>
</tr>
<tr>
<td>GA</td>
<td></td>
<td>Poultry L</td>
<td>3.56a</td>
<td>--</td>
<td>0.99a</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DAP</td>
<td>3.08 b</td>
<td>--</td>
<td>0.90 b</td>
<td>--</td>
</tr>
<tr>
<td>Oliver</td>
<td>Blanton</td>
<td>Control</td>
<td>2.96a</td>
<td>--</td>
<td>0.87 b</td>
<td>--</td>
</tr>
<tr>
<td>GA</td>
<td></td>
<td>Poultry L</td>
<td>3.10a</td>
<td>--</td>
<td>0.96a</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DAP</td>
<td>3.08a</td>
<td>--</td>
<td>0.90ab</td>
<td>--</td>
</tr>
</tbody>
</table>

*Means within a column and soil followed by the same letter are not significantly different at the 5% alpha level using Duncan’s Multiple Range Procedure.
1 gld = groundline diameter, 2 Poultry L = poultry litter @ 1 ton/ac, 3 DAP @ 125 lbs/ac.

A similar “at planting” trial was performed in a slash pine stand in the upper Coastal Plain of Georgia on a Fuquay soil (loamy, Arenic Plinthic Kandiudults). Treatments were (1) poultry litter (4% total-N, 3% P2O5, 2% K2O) at 1 and 2 tons/acre, (2) 125 lbs DAP/acre, and (3) untreated controls (Bush et al. 1999). Weeds were controlled in all plots during the first year. Root collar diameter and total heights of the pines treated with 1 and 2 tons poultry litter/acre + herbicide and the 125 lbs DAP/acre + herbicide were significantly greater than the controls after the first growing season. Height was also greater after the 2nd growing season.

Wilhoit et al. (1998) reported that poultry litter applications of 2-8 tons/acre at pine establishment, without weed control, decreased height one to two years after treatment. When the weeds were controlled, there was a significant growth response.

Dickens et al. (2002) evaluated an at-planting spot application (4 ft²/seedling application
area) fertilization trial in Quitman County, Georgia. In that study, DAP @ 200 lbs/ac (4.6 x 10^3 lbs/ft²) and broiler litter @ 1.5 tons/ac (6.9 x 10^2 lbs/ft²) with or without herbicides were applied to an old-field planted loblolly stand. This site had a high residual fertilizer value in the surface soil. Two-year groundline diameter and height increment means in the herbicide only (H) and herbicide+broiler litter (HP) plots was significantly greater than control (C) and poultry litter (P) only and DAP only (DAP) plots (Table 6). The HP and H treatment means were not significantly different after two years for diameter and height growth. The herbicide+DAP (H+DAP) treatment mean was not significantly different than the HP treatment for 2-year diameter increment but was significantly less than the HP for 2-year height increment (Table 6).

The at-planting results presented by Bush et al. (1998,1999), Wilhoit et al. (1998), and Dickens et al. (2002) suggest that the combination of poultry litter plus herbicide application at planting do as well as or will outperform typical inorganic fertilization. Conversely, poultry litter or inorganic fertilizer application without herbicide use at planting, may be detrimental to stand survival and growth.

Table 6. Two year summary of an old-field planted loblolly pine study in Quitman County, Georgia on Orangeburg and Troup soils. Pine growth responses were evaluated during the first and second winters following treatment. (Dickens et al. 2002).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>1 year ht² (in) increment</th>
<th>2 year ht increment (in)</th>
<th>1 year gld¹ (in) increment</th>
<th>2 year gld increment (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>5.4 b</td>
<td>37.6 c</td>
<td>0.19 c</td>
<td>0.91 c</td>
</tr>
<tr>
<td>Herbicide Poultry²</td>
<td>6.6a</td>
<td>47.3a</td>
<td>0.31a</td>
<td>1.09a</td>
</tr>
<tr>
<td>DAP³</td>
<td>4.8 bc</td>
<td>38.4 c</td>
<td>0.18 c</td>
<td>0.91 c</td>
</tr>
<tr>
<td>Herb+Poultry</td>
<td>5.6ab</td>
<td>45.5a</td>
<td>0.27 b</td>
<td>1.04ab</td>
</tr>
<tr>
<td>Herb+DAP</td>
<td>6.6a</td>
<td>42.2 b</td>
<td>0.31a</td>
<td>1.01 b</td>
</tr>
</tbody>
</table>

²Means within a column followed by the same letter are not significantly different at the 5% alpha level using Duncan’s Multiple Range Procedure.
³gld = groundline diameter, ²Poultry = poultry litter @ 6.9 x 10⁻² lbs ft⁻², ³DAP @ 4.6 x 10⁻³ lbs ft⁻².

**Mid-Rotation**

Several studies have addressed the effects of poultry litter application in early to mid-rotation loblolly pine stands on growth response and water quality. Samuelson et al. (1999) found that two and four tons poultry litter/acre applied in an 18 year-old loblolly pine stand increased stem diameter growth after 18 months.

Dickens et al. (2002) studied the effects of broiler litter applied at 7 tons/acre (450 lbs total-N, 240 lbs PAN, and 170 lbs elemental-P) versus DAP+Urea and no fertilizer treatment in
an old-field, row thinned loblolly pine plantation (treatments applied at age 11 years-old) on an eroded upper Coastal Plain Norfolk soil (fine-loamy, Typic Paleudults). They found that the broiler litter application increased 4-year diameter by 0.54 and 0.61 inch and height by 1.0 to 1.7 feet, respectively over the untreated controls and DAP+Urea (200 N + 50 P) plots (Table 7). Chip&saw (dbh > 8.5") volume in the poultry litter plots (13.5 cds/ac) was 5 cords/acre greater than the unfertilized plots (8.5 cds/ac) four years after treatment (Figure 1). Total value/acre (chip and saw @ $65/cd plus pulpwood @ $15/cd) four years after treatment for the poultry litter plots was $953 and $683 for the unfertilized plots. The rate of return is 28% for extra wood grown ($270/acre) from the poultry litter application assuming $100/acre litter+application cost four years after treatment.

**Effect of Poultry Litter Application on Water Quality**

Beem *et al.* (1998) studied poultry litter applied at 0, 2, 4, 8, and 16 tons/acre and 500 lbs/acre of DAP+urea applied to a thinned loblolly pine stand (down to 110 TPA) in Oklahoma. Litter analysis indicated 60 lbs total-N, 50 lbs elemental-P, and 65 lbs K/ton. They monitored poultry litter and inorganic fertilizer effects on stream and shallow groundwater (soil water @ 1 and 2 feet) quality and stand growth response. They found that the soil water nitrate levels in the 8 and 16 tons/acre poultry litter plots were significantly higher than in the unfertilized plots. The 4 tons/acre and DAP+urea plots had significantly higher nitrate soil water concentrations than the unfertilized plots after one year (tenth storm event). Mean soil water nitrate-N concentrations met EPA drinking water standards (<10 ppm) for all except the 16 tons/acre poultry litter plots. Mean nitrate-N concentrations were significantly higher downgradient of the study area (0.22 ppm) than upgradient of the study area (0.11 ppm) but met EPA drinking water standards. The DAP+urea, 4 and 16 tons/acre had 0.20" diameter growth increase over the unfertilized plots. All fertilizer treatments (inorganic and poultry litter) had greater height growth than the unfertilized plots ranging from an increase of 0.7" (4 tons/acre poultry litter) to 2.8 feet (8 tons/acre poultry litter).

Chastain *et al.* (2002) studied water quality effects of turkey litter applied to thinned 23-year-old loblolly on a Troup soil. They summarized that turkey litter applied at 120 lbs PAN/ac annually in May or November and 300 lbs PAN/ac applied one-time in May or November did not adversely affect groundwater quality with respect to nitrate-N values @ 16-22 feet in groundwater monitoring wells over a three year study. The maximum nitrate-N value was 1.76 mg/l (1.76 ppm) over the three year period.

Terauds-Stirrup *et al.* (2002) found that EPA drinking water standard was met for nitrate-N @ the 5 tons per acre of poultry litter application level but was not met @ the 15 tons per acre level in a loblolly pine plantation in Spaulding County, Georgia.
Table 7. Old-field, row-thinned loblolly pine mean dbh (diameter @ 4.5’) and total height prior to and 2 growing seasons after poultry litter (7 tons/acre) and DAP+urea (250 lbs DAP+335 lbs urea/acre) application (900 TPA prior to thinning and 250/acre after thinning) in the SC Coastal Plain (Norfolk soil).

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Dbh a (in)</th>
<th>Height (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>control</td>
<td>6.16ab</td>
<td>7.98b</td>
</tr>
<tr>
<td>DAP+urea</td>
<td>6.05b</td>
<td>7.94b</td>
</tr>
<tr>
<td>broiler litter</td>
<td>6.30a</td>
<td>8.73a</td>
</tr>
</tbody>
</table>

a Means within a column followed by the same letter are not significantly different at the 5% alpha level using Duncan’s Multiple Range Procedure.

Summary and Conclusions

- When properly applied to pine plantations, poultry litter applications can increase tree growth, pine straw production, and revenue while cutting production costs and benefitting the environment.

- The principle limitation to litter application in pine stands is access. Other limiting factors include hauling distance and number of acres applied/day.

- Poultry litter application rate/level determination depends on pine species, age, stocking, current site fertility, poultry litter characteristics, frequency of application, and soil test-P levels over time.

- Good weed control is required when poultry litter is applied pre- or early post-planting.

- In young longleaf pine stands (mean d.b.h. < 6”) poultry litter application level should not exceed 75 lbs PAN/acre.

- Generally one-time or periodic (every 4 to 8 years) poultry litter application levels up to 5 to 8 tons per acre should meet EPA drinking water standard (<10 ppm) for nitrate-N.

- Pine stands where poultry litter is to be applied should have low (<25-30%) stem fusiform canker incidence and low hardwood stocking (<10 ft² BA/acre) to maximize the growth benefit to the crop pine trees (Dickens 2001).
References


Dickens, E.D., B.W. Richardson and B.McElvany. 2002. Old-field loblolly pine fertilization using DAP+urea and poultry litter - Four year growth and product class distribution results. (Accepted for presentation @ the USFS 12th Biennial Southern Silvi. Research Conf.).

Dickens, E.D., T. Price and B.McElvany. 2002. Micro-site fertilization using Diammonium phosphate and poultry litter at establishment in an old-field loblolly pine plantation. (Accepted for presentation @ the USFS 12th Biennial Southern Silvi. Research Conf.).


Figure 1. Chip and saw (dbh >8.5") volume production 2 and 4 years after the first thinning (November 1997) by treatment (applied April/June 1998) in an old-field loblolly pine stand (Norfolk soil) in Clarendon County, SC.