UTILIZATION OF IN-HOUSE COMPOSTED LAYER MANURE AS A NUTRIENT SOURCE FOR PINE SEEDLINGS

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ABSTRACT

At the present time, animal manures are generally viewed as waste materials with potential for water pollution rather than as a source of valuable plant nutrients that can be used for economic benefit. Much of the current mindset is toward regulation rather than beneficial utilization. To increase the value of layer manure rather than incur additional environmental costs, layer manure produced in a high-rise layer house was composted in the layer house. Beds of sawdust/shavings were placed under the cage rows so that manure excreted by the birds would be deposited on the surface of the sawdusffshavings beds. To promote composting. the sawdustlshavingslmanuremixturewas turned at 2-week intervals for a 246 day period. After this period, the dried compost had a N, P_2O_5, and K_2O content of 2%, 9%, and 5%, respectively. As a control, no sawdustlshavings mixture was placed on an additional 130 ft of manure line. After the same time period, the dried uncomposted layer manure that resulted had a N, P_2O_5, and K_2O content of 2%. 9%, and 5%. respectively.

The P_2O_5-rich compost was evaluated in a greenhouse study to determine if it was a beneficial source of nutrients for the establishment of pine trees in the Georgia coastal flatwoods where the soils tend to be P deficient. Loblolly seedling growth was evaluated where potted seedlings received 0, 2, or 6 tons per acre equivalent of composted layer manure and several mixtures of primary and composted paper mill sludges. Pines receiving the 2-ton composted layer manure demonstrated the best growth rate. The growth rate of seedlings receiving the 6 ton per acre rate was reduced.

This study suggests that the 2 ton per acre composted layer manure rate is acceptable for optimum nutrient utilization. Further experiments should be conducted applying composted layer manure at rates of 0.5, 1.0, 2.5, and 5 tons per acre to determine the optimum application rate for utilization of P.

INTRODUCTION

Increased emphasis on the quality of the environment in the late 1960s led to federal legislation to regulate the discharge of pollutants into the environment. Initial legislation included the Clean Water Act of 1972, which was designed to reduce pollutants discharged from point sources such as municipal and industrial outfalls. During the subsequent 15-yr period, the emphasis was on improving water quality in streams and lakes by reducing point source loading. To further improve water quality. the Clean Water Act was amended in 1987. It placed more emphasis on controlling pollutants from entering streams and lakes from broad areas known as non-point sources, which included areas of agricultural production.

The poultry industry is a highly integrated system of meat and egg production. To gain efficiency, lines of internal supply have been shortened. Feed mills and hatcheries are located close to the grow-out facilities, which are located close to the processing plants. This concentration of birds can lead to the production of more plant nutrients in the manures than locally available land can utilize without having excess nutrients applied to the land.

This concentrated means of poultry production is being impacted by requirements of the Clean Water Act of 1987. In areas of excessive nutrients from manure products it may be necessary to transport some of the manure from local areas to meet requirements of nutrient management plans mandated by the 1987 Clean Water Act.

Layer manure removed from curtain-sided, high-rise layer houses can be characterized as a pasty, black, septic, putrid material. Application of this material near dwellings can cause complaints from neighbors due to odors and fly production. One approach to handle this offensive product is to devise a waste management system that will produce a product which does not have these objectionable properties and may even have market potential, thus increasing profitability of the layer house. This paper will discuss an in-house layer manure management system which has been tested under field conditions in a commercial layer house. In particular, this paper will focus on: the reduction of manure volume, the nutrient content of the manure achieved, and initial studies on utilization of composted manure in pine regeneration.

MATERIALS AND METHODS

Tests were conducted in a 100,000 hen capacity, curtain-sided, high-rise commercial layer house 500 ft long by 40 ft wide located in south Georgia to determine if an in-house layer manure composting system would work under commercial conditions. The test house was chosen because of its concrete floor within the manure area which provided a hard surface for using a prototype mobile compost turner. The layer house was equipped with adjustable curtains which could be raised and lowered to control natural ventilation within the pit area. During the winter months (approximately November to April) the curtains were almost completely raised, allowing only minimal ventilation within the manure area. Tests were started on October 28, 1997, and concluded on July 1, 1998.

All manure was removed from the test area at the start of the study. Windrows of fresh, undried pine sawdust/shavings 130 ft long by 5 ft wide with depths of 5, 10 or 15 in. were placed beneath the cage rows on the cleared concrete floor. Hens deposited their manure directly onto the sawdust/shavings. Hereafter, the treatments will be indicated as 5 in., 10 in., or 15 in. sawdust/shavings, respectively, in reference to their initial sawdust/shavings' depths. An additional 130 ft section of manure line was cleared at the start of this study and the area used as a control treatment to compare against the litter treatments. White leghorns were housed in four-tier, semi-stair stack, A-frame design cage batteries. Each cage was 16 in. wide by 20 in. deep and held six hens. Thus, there were 36 hens per linear ft of manure line under the cage rows.

To aerate the compost and incorporate newly deposited manure into the mixture, the composting material (pine sawdust/shavings and manure mixture) was turned at 2-week intervals using a prototype mobile compost turner built by Farmer Automatic Inc. of Register, GA. The 2-week period was chosen because growers would be less likely to use this system if the compost had to be turned more often than once every 2 weeks. The mobile compost turner was approximately 6.5 ft wide, 6.5 ft tall, and 7 ft long and used a 10 HP gasoline powered engine. The depth at which the tines on the turner operated was adjustable. During the turning process the pit level, side-wall curtains were lowered to provide ventilation within the manure area.

The tines of the compost turner could not be set to floor depth due to the limited power of the prototype compost turner. If a larger engine had been used, more composting would have occurred and even greater reduction in volume could have been achieved.

Greenhouse Study

This study was part of a larger study to test the efficacy of six paper industry sludge materials for growing Loblolly pine seedlings under greenhouse conditions. The bare soil control treatment and a treatment with the 2 and 6 tons/acre equivalent of composted layer manure as a high nutrient benchmark were included and were of particular interest in the present study. Treatment rates in the two sludge categories were referenced to levels commonly used for operational spreading of paper mill sludge on forest land in the southeast. Ten tons per acre is considered a light application unless the sludge is amended with added nutrients. Thirty tons per acre is in the middle range for operational spreading.

The soil used as the potting medium for this study was the Leon Series (thermic, Aeric Alaquods). Leon soils are poorly drained, sandy soil typical of forested flatwood sites in southeast Georgia and northeast Florida. The potting soil was taken from the upper 2 ft of the soil horizon after the leaf litter layer was scraped away. Prior to potting, the soil was sieved, mixed, and cleaned of root sections and other large pieces of organic matter. After potting, the soil was watered and allowed to settle for 10 days prior to planting.

Containerized Loblolly pine seedlings were selected for uniform size and vigor. After application and incorporation of sludge into the soil surface, the seedlings were planted one per pot. Pots were assigned randomly to table positions within the greenhouse in a factorial design. The treatments (six materials + soil-only control) were applied with six replicates within each treatment combination.

The seedlings were grown for a 6-mo period at a greenhouse facility at the University of Georgia Warnell School of Forest Resources. Watering was done as needed with de-ionized water. Height and root collar diameter measurements were made at the beginning and end of the growth period. At the end of the growth period, seedlings were harvested and all biomass above the ground line was dried at 60°C and weighed.

Seedling growth was indexed by height increment, total above-ground dry weight, and stem volume (ground line diameter^2 x height). Seedlings treated with sludge or layer manure were compared to the bare soil control group and to the other treatments, since a significant treatment effect occurred with all three response variables.

RESULTS AND DISCUSSION

Reduction in Manure Volume Using In-House Composting

The volume per linear ft for each treatment over the 246 days of testing is shown in Figure 1. On day 246 the raw manure had the largest pile volume, followed by the 5, 10 and 15 in. sawdust/shavings treatments. The volumes of the 10 and 15 in. compost piles were approximately the same between days 100 and 246. Many of the properties (volume, moisture content, pile temperature, and nutrient density) were similar between these two treatments. Both the 10 and 15 in. sawdust/shavings depths were sufficient to allow composting to occur at this bird density and manure deposition rate over the duration of this experiment.

Nutrient Composition of the Compost

The nutrient density of the raw manure and the three different compost treatments after 246 days of testing is shown in Table 1. Five in. of shavings were insufficient for composting (after approximately 100 days) and the treatment became septic. The moisture content of this treatment was much higher than either the 10 in. or 15 in. treatments. By in-house composting, the product would leave the house with a dry basis nutrient density of approximately 2% N, 8.7% P_2O_5, and 5.8% K_2O. This product had the odor much like that of composted manure and leaf mixtures.

Patterson and Lorenz (1996) reported that the nutrient density of commercial layer manure for samples taken from eight different flocks of birds housed in fan-ventilated commercial layer houses after long-term manure storage ranged from 1.98 to 9.42% N, 2.71 to 11.73% P_2O_5, and 2.16 to 5.72% K_2O. The values reported in this experiment are between those reported by Patterson and Lorenz for high and low nutrient density, with the percent N closer to those reported for the low sample. Percents of P_2O_5 and K_2O were in the middle of the Patterson and Lorenz reported range. The variation in nutrient density of layer manure was attributed to age of the birds, bird diet, and management of the manure. In the present study, composting had little effect on the dry basis nutrient density of the manure. However, the moisture content of the raw manure was much higher than any of the three treatments in the present study. Obviously, this decrease in moisture content with the three sawdust/shavings treatments is related to the decrease in manure weight and volume noted in this study. In-house composting resulted in the same amount of nutrients in a smaller amount of more easily handled, less objectionable material.

The estimated accumulation of manure weight in each pile and the percent reduction in manure weight is shown in Figure 2. Sections for each pile were weighed. The weights of the 10 in. and 15 in. sawdust/shavings treatments were very similar throughout the experiment and were approximately the same on day 246. On day 246, a 39% reduction in weight on average was observed for these two treatments over that of the raw manure. This reduction in weight of the composted material was due to drying of the material as well as decomposition of organic substances within the manure/sawdust/shavings mixture as would normally be observed in a composting process.

If this system had been implemented in the whole house, the 15 in. sawdust/shavings compost system would have produced 11,700 ft^3 and 400 tons less material over the course of the experiment than the manure collection system that received no treatment. The manure line which received 10 in. of sawdust/shavings produced results similar to the line that received 15 in. of sawdust/shavings, whereas, the line which received 5 in. of sawdust/shavings reacted in a manner similar to the untreated line. The compost material had a final dry weight nutrient concentration of 2% N, 8.7% P_2O_5, 5.8% K_2O, and 16.9% Ca. Untreated layer manure contained a similar dry weight nutrient density. However, due to its higher water content, wet weight nutrient densities were approximately 1/3 less than the composted material. In addition, the sensory properties of the composted material were much more pleasant than the raw manure. The compost had an earth-like odor similar to leaf mold, whereas the untreated manure had the putrid, septic odor associated with layer manure.

Greenhouse Study

In an earlier study (Bush, Merka, and Morris 1997), survival of greenhouse-grown Loblolly pine seedlings was poor following application of fresh poultry manure. Foliage symptoms were consistent with ammonium toxicity. This survival problem may be reduced or eliminated by allowing poultry manure or poultry manure-primary sludge mixtures to compost for a period prior to application to young seedlings or by reducing application rates.

The greenhouse study results (Table 2) show that composted layer manure applied at 2 and 6 tons per acre significantly increased above-ground mass production by a factor of 3.89 and 3.17, respectively, over the control. However, the composted layer manure treatment showed the highest mortality across the two application rates, with 4 of 12 class replicates dead at the end of the study. Previous field studies (Bush, Merka, and Morris 1999) showed that pelletized broiler litter (3-3-2) applied at the rate of 1 and 2 tons per acre would stimulate pine seedling growth equally as well as commercial fertilizer applied at a rate of 125 lb of 18-46-0 per acre. Little pine mortality was observed in the field study.

SUMMARY

Since P is often a limiting nutrient in Coastal Plain forest pine stand establishment, it was of interest to investigate the use of composted chicken manure as a P source during stand establishment. In addition to supplying the P requirement, the composted manure would also supply other essential elements for pine growth and increase soil organic matter. The Ca (CO_3) present would also tend to raise the soil pH, making nutrients more available.

If a soil test shows P levels less than 10-12 lb per acre, then the standard recommendation (Moorhead 1999) is to apply 40-50 lb of elemental P at planting. If composted manure has a fertilizer value of 1.9-8.9-4.8 (Table 1), then 1286 lb dry weight of composted manure per acre (1.5 tons wet weight per acre) would be needed to meet P requirements at pine planting. Since current spreader equipment is limited in its ability to apply less than 2 tons of litter per acre to forested land, an application rate of 2 tons per acre appears to be a good target application rate. An application of 2 tons per acre (wet weight) would result in 42 lb of N and 62 lb of elemental P per acre. This is slightly higher than the recommended fertilization rate but should not overload the system's ability to assimilate the N or P.

Weed control is a critical component in stand establishment and is required if litter or composted layer manure is used. Auburn University studies (Wilhoit, Ling, and Samuelson 1996) reported that litter applications of 2-8 tons per acre at pine establishment, without weed control, decreased height growth 1 and 2 yr post-treatment. If weeds were controlled, there was significant growth response. Previous studies with pelleted chicken litter (Bush, Merka, and Morris 1999) showed significant growth from application of 1 ton of poultry litter to Loblolly and Slash pine at planting with first-yr weed control. Weed control during stand establishment may add \$40-\$93 per acre but usually is cost effective.

In Table 1 it is shown that a standard 100,000 bird layer house will produce 868 tons (wet weight) of composted litter per yr, which will contain 83,300 lb of P_2O_5. If the litter application rate is 2 tons per acre, then each house would produce enough composted litter to treat 434 acres. Each yr the layer industry of Georgia produces enough layer manure to meet the P requirement of 154,000 acres of pine tree seedlings. If the grower could get 1/2 the nutrient value of the fertilizer or \$40 per ton, he would increase the profitability of each house by 20%. (Fertilizer value is based on \$0.30 per lb for N, \$0.25 per lb for P_2O_5, \$0.12 per lb for K_2O, and \$0.015 per lb for Ca.)

When addressing poultry litter/compost applications, 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, then a nutrient management plan would maximize the economic advantages of nutrients and minimize undesirable off-site effects such as N or P movement in surface runoff or to groundwater. If, however, the objective is to dispose of waste, greenhouse studies show that litter can be applied at 6 tons per acre without inhibiting pine growth. It remains to be determined if newly planted pine stands can assimilate the 228 lb of N (137 lb available N) without allowing nitrate-N to leach to groundwater in excess of the 10 ppm nitrate-N drinking water standard. This can be a potential problem on sandy soils with a shallow water table.

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Table 1. Nutrient density of the manure and compost on a percent dry-matter basis after 246 days (October 28 to July 1) of testing. In parenthesis are shown the lb/ton on an "as-is" basis for each treatment.

	N	P_2O_5	K_2O	Ca	Mg	H_2O	Estimated Annual Production per 100,000 Hens
	%					%wb	--tons--
Raw Layer Manure	2.1 (15)	8.6 (63)	5.4 (39)	15.7 (114)	0.8 (6)	64	1498
5 In. Treatment	1.9 (17)	7.2 (63)	2.2 (20)	16.9 (148)	0.7 (6)	56	1279
10 In. Treatment	2.0 (23)	8.5 (102)	6.9 (82)	18.5 (222)	0.8 (10)	40	957
15 In. Treatment	1.9 (21)	8.9 (99)	4.8 (54)	16.9 (188)	0.9 (10)	44	868

Table 2. Dry weight of Loblolly pine seedlings grown in surface soil from a Coastal Plain site amended with composted wastes after 6 mo in the greenhouse

Treatment	Equivalent Application Rate ($t \times ac^{-1}$)	Height (cm)	Ground-Line Diameter (mm)	Above-Ground Mass (g)
Control		37.6	6.4	4.8
Composted Layer Manure	2	63.2*	8.6*	18.7*
	6	59.6*	8.5*	15.2*
Composted Primary Paper-Mill Sludge	10	56.1*	6.2	6.1
	30	56.3*	7.2*	11.6*
Composted Secondary Paper-Mill Sludge	10	60.0*	8.3*	12.5*
	30	66.6*	9.3*	20.3*

*Significantly greater than control (= = .05)

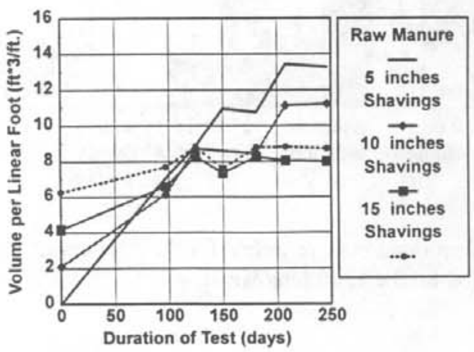

Figure 1. Volume (ft^3) per linear ft of the compost piles and dry stacked raw manure over 246 days of testing

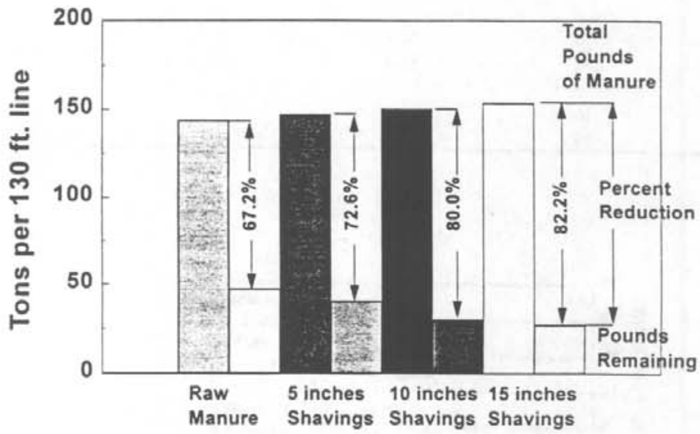

Figure 2 Percent reduction in manure weight for the different treatments over the 246 day test period for the 130ft long windrows