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Composting - A Feedlot Waste Management Alternative

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Summary

A composting operation was initiated in 1993 in cooperation with the Integrated Farm Project at the Agricultural Research and Development Center (ARDC) Beef Feedlot. Compost was hauled from the feedlot and placed in windrows, where it was turned for composting. In 1993, a very wet year, 2500 tons of beef feedlot manure were composted. The compost contained a considerable amount of soil and only averaged 4.3 lb of N/ton and 5.6 lb of P/ton. In 1993, a front-end loader was used to turn the compost for most of the year. In 1994, a pull-type compost turner allowed compost to be turned in a more timely manner and the compost contained 12.4 lb of N/ton and 7.7 lb of P/ton. Costs for composting were $3.50/ton in 1993 and $3.75/ton in 1994. A nutrient recovery experiment indicated that 67 to 76% of OM and 64 to 77% of N was recovered during composting, depending upon the feedlot diet. Check strips established in fields where compost was applied indicated a crop response on soils low in OM and P.

Introduction

Implementation of nitrogen management plans by Natural Resource Districts may require feedlots to evaluate the environmental soundness of their waste management plans. Composting may be a manure management system that can provide a method of using the nutrients in feedlot manure as a resource in an environmentally sound manner. Composting is an aerobic (oxygen requiring) decomposition of organic matters, such as manure, by microorganisms. Composting has been shown to provide many benefits. Moisture content and volume of composted feedlot manure are reduced 50% compared with raw feedlot manure. This improves handling and requires fewer trips to the field when applied to cropland. It may also be economically feasible for compost to be transported longer distances and be used as a valuable resource for crop production. Composting stabilizes nitrogen and makes it less susceptible to leaching and runoff when surface applied. This also provides flexibility in application to cropland. Unlike raw manure, compost does not have to be incorporated into the soil immediately following application to prevent nitrogen losses. Odor is generally reduced compared

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with stockpiled manure; and land applied composted feedlot manure is nearly odorless.

Drawbacks to composting include: time, money, land, and potential loss of nitrogen. Composting takes considerable labor, time and careful management if done properly. It may require the purchase of additional equipment to turn the windrows. Adequate land is needed for properly locating the composting site so it can function correctly. Runoff needs to be controlled, but adequate drainage is required to reduce muddy conditions during wet periods. In composting feedlot manure, loss of nitrogen from volatilization of ammonia is a major concern. Compost may contain only 50% of the nitrogen that was in raw manure. This may be due to a low (C:N) ratio, approximately 15:1. While adding carbon sources to the feedlot manure would reduce this problem, it usually is not economically feasible unless a source is delivered to the site free or a fee is received for the carbon source.

The objectives of this study were: 1) Determine the cost of composting beef feedlot manure, 2) Determine the nitrogen and phosphorus content and economic value of composted feedlot manure, 3) Calculate the recovery of organic matter and nitrogen during the composting process, and 4) Evaluate crop response to application of compost.

Procedure

The 1200 head feedlot at the Agricultural Research and Development Center began composting in the spring of 1993. A site was selected in the fall of 1992 for composting. The site was located so runoff from the windrows of composting feedlot manure would be contained and flow into a swine lagoon. Manure was hauled out of the feedlot and put in windrows three to five ft high and 12 to 15 ft wide. Windrows were then turned periodically as the temperature of the windrows heated to 140 to 160° F during the composting process. A front-end loader and a specially designed compost turner were used to turn the windrows. Turning the windrows served two purposes. First, it aerated the material to replenish it with oxygen so the composting process continued; and second, it cooled down the windrow to reduce nitrogen losses from volatilization of ammonia. When the composting process worked correctly, water, heat, and CO_2 were generated.

Costs for turning and spreading compost were estimated per ton of compost produced during 1993 and 1994. In 1993, costs were based on $10/hr for labor, $20/hr for rental of loader, $19.50/hr rental on the tractor, and $500 for one month rental for the compost turner or $.20/ton of compost. Spreading costs were based on a computer model developed by Ray Massey, Extension Specialist, Agricultural Economics. These costs are calculated using several variables that are entered into the equation. These variables include: spreader cost, $20,000; spreader life, 10 years; diesel price, $.75/gallon; wages, $10/hr; road speed, 15 mph; field speed, 6.5 mph; field size, 60 acres; distance to the field, 1 mile; tons per acre, 10; spreader capacity, 15 ton; and swath width, 17 feet. These variables provided the information for this model to give an estimate of the average costs of spreading compost in 1993. In 1994 costs were similar for labor, loader rental, and tractor rental. Cost of rental of the compost turner was $500/month, for a five month period. Beef feedlot manure was turned an average of four times during this period. The cost of the turner was $.60/ton of compost. In 1994, the spreader was recalibrated to improve the accuracy of compost application. Average spreading costs were calculated using the computer model, with the following variables being used: field speed, 6.3 mph; distance to the field, 3 miles; tons per acre, 12; and swath width, 12 feet.

An experiment was also conducted to determine recovery of N and OM from three different finishing diets. A diet containing 7.5% roughage, a wet corn gluten feed diet, and an all concentrate diet were fed to finishing cattle in the feedlot (Bierman et al., p 74). Following completion of the trial, manure from pens on each diet was collected, weighed, hauled to the compost site, sampled, and analyzed for N and OM before composting. Manure from each pen was composted separately. After the manure was composted, it was sampled and analyzed for N and OM to determine recovery of these nutrients using ash as an internal marker.

In 1993 and 1994, check strips were established in fields where compost was applied as a P source and were supplemented with commercial N according to soil tests for the subsequent crop. The check strips also received commercial N, but no compost. Paired comparisons for yield between strips were made in 1994 for wheat, soybeans, and corn.

Results

Dry matter, N, and P content of compost in 1993 were 83.2%, 4.3 lb N/ton, 5.6 lb P/ton on an "as is " basis. The very wet year of 1993 made composting feedlot manure difficult. It was difficult to clean pens in a timely manner, and a considerable amount of soil was hauled from the pens with the manure to the compost site. This material did not compost well as it did not heat properly. The manure was too wet early in the summer, or too dry when the pens were cleaned in late summer. Ideally, material for composting should range from 40 to 65% moisture, have a carbon to nitrogen (C:N) ratio of 20:1 to 40:1, and temperature range of 110 to 150°F. If the material is too wet, oxygen will not be sufficient, and anaerobic decomposition of the material will occur. Anaerobic processes generate little heat to evaporate water, and produce methane, hydrogen sulfide, and other organic substances that cause strong odors. If the moisture content of the material is below 40%, it is difficult to initiate the composting process and the material will compost very slowly. If the C:N ratio is below 20:1, the available carbon is fully utilized before all of the nitrogen is stabilized resulting in excess nitrogen being lost to the atmosphere as ammonia or nitrous oxide. The low nitrogen content of the compost was attributed to nitrogen either volatilized in the pens as ammonia or washed away in the runoff. Initially, the windrows were turned with a large payloader. The loader did not aerate the manure very well. In late summer, a pull-type compost turner was leased. The compost turner did a much better job of aerating the manure and getting the composting process started. Despite all the difficulties, 2500 tons of compost were produced from the feedlot.

In 1994, average dry matter, N, and P content of compost were 77.3%, 12.4 lb N/ton and 7.7 lb P/ton of compost. With considerably less rainfall in 1994, composting of beef feedlot manure went very well. The pens were cleaned in May and June in a timely manner and the manure had much lower soil content. The windrows were turned an average of four times during the summer. Temperature of the compost was monitored in the windrows. Windrows were turned as temperatures reached 140 to 150° F. The lower temperatures reduced the amount of nitrogen volatilized as ammonia during composting. Research at the ARDC *(Eghball, personal communication)* has shown that from 15 to 40 % of the N from manure is lost during composting depending upon the diet fed to the cattle and initial N content of manure. Although lower temperatures during composting may reduce N losses, they may also limit the destruction of weed seeds. While only 500 tons of compost were produced in 1994, it was higher in nutrient value than in 1993.

The higher nutrient content of the compost in 1994 increased its value considerably. Compost was priced according to its N and P content, based on commercial fertilizer value of N and P. Based upon prices during the spring of 1995, $.19/lb for N and $.58/lb for P, value of composted feedlot manure was $4.07 and $6.82/ton for 1993 and 1994, respectively.

Costs for labor, turning and spreading compost were estimated to be $3.50/ton in 1993. Costs were based on $1.25/ton for turning the compost and $2.25/ton for delivery to the field, and spreading the compost. These costs do not include costs associated with cleaning of the pens and hauling to the compost site. In 1994, costs were $3.75/ton for producing compost, delivering it to the field, and spreading the compost. Cost of turning and spreading the compost averaged 1.25/ton and $2.50/ton, respectively.

Table 1. Effect of compost application on crop yields in 1994.

Treatment	Crop	Yield (bu/ac)
Compost applied	Soybeans[a]	55
No compost applied	Soybeans[a]	58
Compost applied	Soybeans[b]	54
No compost applied	Soybeans[b]	49
Compost applied	Wheat	58
No compost applied	Wheat	55
Compost applied	Corn	123
No compost applied	Corn	114

[a]Soil conditions were a silty clay loam, OM 3%.
[b]Soil conditions were a sandy loam, OM 1.5 to 2%

Results of the nutrient recovery experiment showed a 67.0, 70.6, and 75.6% recovery of organic matter for the 7.5% roughage, WCGF, and all concentrate diets respectively. The recovery of N for these respective diets was 65.5, 63.9, and 76.5%. The recoveries for OM and N after composting are in the range of previous research results.

Yield results of paired comparisons to evaluate the effect of compost application on crop yields are shown in Table 1. Results indicate crops tended to respond to compost more when applied on poorer soil. In a large 75-acre field which tested low in P, compost was applied following corn during the fall and winter of 1993-94. Two check strips were established, one on a silty, clay loam soil higher in organic matter (3%), and the other on a sandy, loam soil with a lower organic matter (1.5 to 2%). In 1994, yield comparisons on soybeans in this field showed no yield response on the soil higher in organic matter, but a 10% increase (5 bu/acre) on the lower organic matter soil. In 1995, additional check strips will be compared to evaluate the effect of compost on crop production.

Conclusions

Results of this study indicate that successful composting is highly dependent upon the material that is delivered to the compost site from the feedlot pens. Manure that is very wet or dry and contains considerable quantities of soil will not compost well and nitrogen content of compost is low. When manure is lower in soil content and contains sufficient moisture, it will heat up when put in windrows. The composting process will continue and go to completion if the windrows are turned when temperatures reach 140 to 150°F. This method will conserve the most nitrogen and add value to the compost. This study suggests the value of the N and P in the compost will pay for the cost of composting. The effect of compost on crop yields indicates compost is best utilized on poorer soils low in organic matter and as a phosphorus source. Based on these results, compost is being used on the ARDC as a P source for crops. It is being applied during the fall and winter to fields that have soil tested low in P. Compost is also being used as a P source for established alfalfa and also before planting alfalfa. Compost is being applied at rates from 8 to 12 ton/acre to supply enough P for two or more years, depending upon what crops are grown. Compost is being prioritized for use in fields low in P, under irrigation, and for alfalfa production. The method of compost application being used on the ARDC provides for a systematic application of P and a stabilized form of N that is released slowly to the crops. This reduces the risk of ground and surface water contamination. Composting has allowed flexibility in our application times without the risk of polluting our environment and causing soil compaction. It may provide additional benefits to the soil that will be identified over time.

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