DETERMINING PLANT AVAILABLE NITROGEN FROM MANURE AND COMPOST TOPDRESSED ON AN IRRIGATED PASTURE

Kathy Corwin Doesken, Jessica G. Davis, Adriane L. Elliott, and Troy Bauder
Colorado State University Soil and Crop Sciences Department, Research Associate, Professor, Water Quality Extension Specialist, Fort Collins, CO 80523-1170

ABSTRACT

Composting manure is a practice that is gaining acceptance as an environmentally sound manure management practice at large animal production operations. Composting produces a value-added product that enhances the fertility and physical properties of soil. During the composting process, nitrogen and phosphorus in the original feedstocks are converted through microbial activity into predominantly stable organic compounds, lessening the risk of loss of these nutrients into the environment. Compost is generally marketed as an amendment for use in urban soils. Potential exists for marketing compost for agricultural use. However, the effect of compost on soil fertility is not well understood. While the rate at which nitrogen from manufactured fertilizers becomes plant available is highly predictable, the rate at which nitrogen from compost becomes plant available is not well defined. This rate depends on several interacting factors, including soil type, organic matter content, climate, soil microbial activity, and cultural practices. Site specific data is needed to develop a database from which compost application rates can be established for irrigated pastures.

This field study uses the ion-exchange resin/soil core method to measure available nitrogen in soils amended with compost, manure, and commercial fertilizer during the growing seasons of 2006 and 2007. Preliminary data from the 2006 growing season shows that manufactured fertilizer releases the most plant available nitrogen early in the growing season. However, as this study progresses, more data will become available about the amounts of nitrogen released more slowly from the manure and compost applications. Forage yield will also be evaluated to determine the effects of the soil amendments on plant growth.

INTRODUCTION

Livestock production generates manure, which is often classified as a waste product. However, manure can be a useful by-product of the livestock industry when it is used to enhance the physical and chemical properties of soil. Manure can also be composted to produce a value-added product that further enhances the chemical and physical properties of soil. Manure and compost can substitute for part or all of the manufactured fertilizer needed for plant growth. The process of manufacturing fertilizers is reproducible, and the results of applying manufactured fertilizer to soils are predictable. However, manure and compost are derived biologically and are inherently variable.

The fate of the nutrients in composts is challenging to predict. Successfully predicting how much of the total nitrogen in a compost will become available for plant growth can depend on multiple factors, such as the original feedstocks used to make the compost, the compost's quality and maturity, physical and biological properties of the soil to be amended, climate, and management practices. These diverse factors make determining appropriate compost application rates challenging. However, applying compost at appropriate application rates is critical to its effectiveness and widespread use. Applying too little compost results in poor plant performance which is a disincentive to using compost. Applying more than enough to satisfy the nutrient requirements of plants can add unnecessary cost to production, which is another disincentive to using compost, and can result in environmental problems due to over-application of nutrients.

The objective of this study is to measure the amount of nitrogen in manure and compost that becomes plant available when applied to an irrigated grass pasture. This plant-available nitrogen is termed mineralized nitrogen, and includes the inorganic forms of nitrate (NO_3-N) and ammonium (NH_4-N) nitrogen.

Recent and ongoing land use changes in Colorado show a decrease in large holdings of irrigated agricultural land and an increase in smaller land units used for commercial and non-commercial horse farms. There is a lack of information applicable to Colorado about nitrogen mineralization from horse manure, horse manure mixed with high carbon bedding, or composted horse manure topdressed onto pastures, which is a typical management practice on small acreages where horses are kept. A recent study at Colorado State University (Johnson et. al., 2006) has shown the value of topdressed compost on turfgrass, but the results are not directly applicable to grass pastures. This field study is being conducted on a mixed grass pasture suitable for horse grazing in northern Colorado, using composted and uncomposted horse manure, and manure mixed with high carbon bedding so that the results can be applied to pasture management on small acreages. The results of this study can also be applied to organic pasture management, which is a growing interest in this region due to the presence of organic dairy operations.

This study will also add to the quantifiable information available about mineralization of nitrogen from composts, and enable agricultural compost users to better utilize this material. Increased use in agriculture has been identified by Colorado compost producers as a goal in marketing increasing volumes of compost.

METHODS

The study is being conducted under a linear move sprinkler on an established stand of cool season perennial grasses (approximately equal proportions of *Dactylis glomerata*, *Bromus inermis*, *and Bromus bibersteinii*,) at the Agricultural Research, Development, and Education Center (ARDEC), located northeast of Fort Collins, CO, operated as a research farm by Colorado State University. This study uses the ion-exchange resin/soil core method (IER/SCM) (DiStefano and Gholz, 1986) to measure nitrogen mineralization in the field. In this method, small bags of resin are placed at the bottom of tubes inserted in the ground to capture nitrogen that moves down in the soil profile. Previous studies (Jakubowski, 2001) have shown that 20 mL of ion exchange resin is adequate to prevent leachate from moving past the resin bag (Jakubowski, 2000). Twenty mL of ion-exchange resin, which consisted of equal amounts of Na-saturated cation (US Filter C-211) and Cl-saturated anion (US Filter A-464) exchange resins were placed on squares of cloth made of Lycra® (5 inches by 5 inches). Lycra® cloth was used for maximum durability in the soil. The cloth was gathered up into a small bag, the top was twisted and fastened tightly using an upholstery staple fastening tool to prevent any ion-exchange resin from leaking out.

Galvanized metal tubes 6 inches high and 2 inches in diameter were placed in the soil between April 11 and April 13, 2006. A one inch space remained unfilled at the top of the tubes to leave space for soil amendments. The tubes were inserted into a one year old irrigated grass pasture mix typical for use in a northern Colorado horse pasture using a tool manufactured by Giddings Equipment (Windsor, CO) and Giddings manufactured soil sampling hydraulic equipment mounted on a pickup truck. The experimental design is a completely randomized block design, with six treatments replicated four times. Each subplot is 20 feet by 40 feet. Thirty tubes were inserted at random locations in each of the 24 subplots so that 5 tubes could be sampled three times during each of the growing seasons of 2006 and 2007.

We inserted a tube into the soil, the tube with its intact soil core was withdrawn from the soil using the truck's hydraulics, and the soil core was adjusted to fit the tube. The bottom of the soil core was cut level with the bottom of the tube with a knife, and the Lycra® resin-containing bag was positioned at the bottom of the intact soil core. A piece of ripstop nylon was used to cover the resin bag and hold it tightly to the bottom of the tube. The nylon holding the resin bag to the bottom of the tube was fastened with duct tape, and reinserted by hand into the hole from which it was removed. Each tube was marked with a surveyor's plastic fringe spiked into the ground next to the tube so that it could be located during sampling times later in the growing season when the grass was tall. These plastic markers were color coded to mark the control tubes to which no amendment was added.

Soil amendments (Table 1) were two rates of composted horse manure, two rates of horse manure, one rate of horse manure and wood shaving bedding material, and one rate of urea at the agronomic rate for this crop (based on soil samples taken the previous fall). While the main focus of this study is nitrogen that becomes available from compost, the results will possibly have more meaning when compared to conventional fertilization with urea and commonly applied manure rates.

Table 1. Soil amendment treatments.

Treatment #	Type of Amendment	Rate of Application
1	Composted horse manure	10 T /A
2	Composted horse manure	20 T / A
3	Horse manure	10 T / A
4	Horse manure	20 T / A
5	Horse manure + wood shavings	10 T /A manure + shavings (60:40 by vol.)
6	Urea (46-0-0)	185 pounds N / A

Pre- weighed amendments were added to each tube according to the completely randomized block design from April 27 to May 2, 2006. These tubes were then reinserted into the plots in the location where they were removed. The tubes were covered with aluminum foil caps while the six soil amendments were applied to the 24 field plots between May 3 and May 5, 2006.

In 2006, tubes were removed three times during the growing season, on June 30, August 22, and October 16. After sampling, soil tubes were stored on ice in a cooler. Soil was removed from the tubes and air dried in a walk-in cooler at 40^{o} F to retard biological activity in the soil which could result in changes in ammonium and nitrate. The soil was ground to pass through a 2 mm sieve and weighed. Ammonium nitrogen and nitrate nitrogen were determined by weighing out a 5 g sample from each tube, extracting it with 50 mL of 2 N KCl, and shaking for 30 minutes. Extracts were filtered gravimetrically, and analyzed for ammonium and nitrate nitrogen.

Resin bags were removed from the tubes and stored in a cooler until they were analyzed. Each resin bag was placed in a 250 mL Erlenmeyer flask, 180 mL of 2 N KCl was added to it prior to being shaken for 30 minutes. Extracts were filtered gravimetrically. This procedure was repeated twice, resulting in three extractions from each sample. Equal aliquots of extractant were added together to make a 20 mL sample, which was analyzed for ammonium and nitrate nitrogen. Two sampling dates of data were available at the time this paper was written. Data from the third sampling date will be available before the presentation is made.

Plant yield was measured twice during the growing season. Results are given in Table 2. Just prior to mowing the entire set of plots for hay, borders three feet wide were cut between plots. A three foot wide strip was mechanically harvested in each plot with a forage harvester. Total wet weight of this strip was taken. Three grab samples of this plant material were sampled to determine moisture content. The three samples were composited, weighed wet and oven dried at 158^{o} F for three days. The bags were reweighed after 3 days. Percent moisture was determined so that harvested material could be converted to dry matter yield.

RESULTS AND DISCUSSION

In June, the three highest yielding treatments were urea at an agronomic rate, compost at the lower rate of 10 T/A, and manure at 10 T/A with wood shavings added (Table 2). These are very diverse treatments which each resulted in good plant response. The lower rate of compost supplied enough nutrients for good plant growth without suppressing early growth in the grass stand. The higher rate of compost, which contained more nutrients, could have suppressed the early grass growth because of its depth, which was about 1 inch. The manure treatment mixed with wood shavings may have had a mulch effect upon the soil which resulted in more plant available water. This treatment, when topdressed, was as deep as the compost at the higher rate, but the woody addition to the manure was less dense than the compost, perhaps resulting in a beneficial mulching effect instead of a smothering effect.

August yields showed no differences among the treatments. However, the combined yields from June and August resulted in no significant differences in the four top yielding treatments, which were the two rates of compost, the agronomic rate of urea, and the lower rate of manure plus wood shavings.

The 2007 field season will provide additional data that may elucidate patterns of nitrogen mineralization from these three different sources of nitrogen the second year after topdressing.

Table 2. Grass hay yield in 2006.

	Dry Matter Yield (T/A)		
Treatment #	June 8, 2006	August 10, 2006	June + Aug.
1 (compost rate 1)	1.2 ab	1.2 a	2.4 a
2 (compost rate 2)	0.7 b	0.9 a	1.6 ab
3 (manure rate 1)	0.6 b	0.5 a	1.1 b
4 (manure rate 2)	0.7 b	0.6 a	1.3 b
5 (manure 1 + C)	1.4 ab	0.8 a	2.2 ab
6 (urea @ 185 lbs./A)	1.9 a	0.9 a	2.8 a

Results followed by a common letter are not significantly different ($p<0.05$) by Least Significant Differences.

Results from the June sampling show that treatment 6, the agronomic rate of urea, resulted in significantly higher amounts of nitrogen availability than any of the other treatments (Table 3). This result was expected, as both manure and compost release nitrogen more slowly than does manufactured fertilizer. By the second tube sampling, nitrogen available from the urea had decreased but was still significantly higher than any of the other treatments. The lowest rate of compost showed the next highest amount of nitrogen mineralized. There is not enough data yet to speculate why less compost resulted in more plant available nitrogen. Treatment 5 experienced significant immobilization of N (represented as a negative mineralization rate) due to the high carbon content of the bedding material. From a pasture management perspective, manure at 10 T/A plus a carbon-rich bedding material showed good yield results, even when the nitrogen mineralization results (Table 3) showed that this treatment resulted in net nitrogen immobilization, as shown by the large negative value of net nitrogen mineralized (-24 pounds /A), which was significantly less nitrogen mineralized than in all the other treatments. The October sampling will provide more information about what is happening over time among the six treatments. That data will be available in late January, and will be included in future presentations of this research.

Table 3. Net nitrogen mineralization from soil amendments.

	Net Nitrogen Mineralization (pounds /A)		
Treatment #	June 30, 2006	August 22, 2006	October 16, 2006*
1	9.9 b	22.2 b	
2	11.2 b	5.3 c	
3	-0.4 b	-6.1 c	
4	6.5 b	-4.7 c	
5	1.0 b	-24.0 d	
6	126.0 a	57.4 a	

Results followed by a common letter are not significantly different ($p<0.05$) by Least Significant Differences.

SUMMARY

The results to date are inconclusive. Addition of the October 16 sampling data may show further trends in the amount of N mineralized over the entire first growing season.

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*Results available in late January 2007.

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Program Chair:
John Hart
Oregon State University
Corvallis, OR
(541) 737-5714
john.hart@oregonstate.edu

Publicity Chair:
Richard Koenig
Washington State University
Pullman, WA
(509) 335-2726
richk@wsu.edu

Coordinator:
Phyllis Pates
International Plant Nutrition Institute
Brookings, SD
(605) 692-6280
ppates@ipni.net