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Corn Bran Level in Finishing Diets and N Losses from Open-Dirt Pens

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Liming Effects of Beef Cattle Feedlot Manure and Composted Manure

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Beef cattle feedlot manure or composted manure usually contain 1% to 4% calcium carbonate and therefore can be used as lime sources on acid soils.

Summary

Soil pH can be increased by manure or compost application because cattle rations usually contain limestone (calcium carbonate). From 1992 to 1996 this study evaluated effects of phosphorus and nitrogen-based manure and compost applications (annual and biennial) management strategies on soil pH level. Manure and composted manure contained about 0.9% calcium carbonate resulting in application rates of up to 1,540 lb lime per acre in four years. The surface soil (0-6 inch) pH was significantly decreased with ammonium-N fertilizer application as compared to soil in the unfertilized check or to soil receiving manure or compost. Nitrogen-based applications resulted in higher soil pH than P-based, since P-based treatments also received N fertilizer.

Introduction

The recommended calcium level in beef cattle diet is 0.7% or about 1.5% calcium carbonate. Much of the added calcium carbonate is excreted in manure, which typically contains 1% to 4% calcium carbonate on a dry weight basis. Calcium carbonate is also added to swine and poultry diets.

About 70% of the cattle fed in the United States are in the Great Plains region where soils usually have high pH levels. Even within the Great Plains, areas where N fertilizer has been used for several years, soil pH has been reduced to levels where lime application is recommended for an optimum crop production level, especially in sandy soils. The objective of this study was to evaluate effects of application frequency and N or P-based rates of manure and compost applications on soil pH changes.

Procedure

An experiment was initiated in 1992 on a Sharpsburg silty clay loam soil under rainfed conditions at the University of Nebraska Agricultural Research Center near Mead, Neb. The initial soil had a Bray and Kurtz No.1 soil P level of 69 ppm and a pH of 6.2 (1:1 soil to water ratio) in the top 6 inches. The experimental design was a randomized complete block with four replications. Plots were 40 feet long and 15 feet wide (six corn rows). Ten treatments were applied which included annual or biennial manure or compost application based on N or P needs of corn (135 lb N/acre and 23 lb P/acre for an expected yield level of 150 bu/acre) and fertilized and unfertilized checks. Fertilized plots received 135 lb N/acre as ammonium nitrate and 23 lb P/acre as diammonium phosphate. If necessary, the P-based treatments (annual or biennial application) also received N fertilizer as ammonium nitrate to provide for a total of 135 lb available N/acre for the corn.

Beef cattle feedlot manure and composted feedlot manure were applied in 1992 based on the estimated plant N or P availability of 40%, 20%, 10%, and 5% of the N and P in manure or compost in the first, second, third, and fourth year after application, respectively. The first-year N availability assumption from compost was found to be too high, so availability assumptions were changed to 20%, 20%, 10%, and 5% for compost applications after 1992. The same N availability assumptions as 1992 were used for manure in all years. Phosphorus availability assumptions from manure and compost were changed to 60%, 20%, 10%, and 10% after 1992. Biennial manure or compost application was made to provide 135 lb N per acre for N-based and 23 lb P per acre for P-based rates in the second year after application based on the assumptions given above.

Manure and compost applications were made in late autumn after corn harvest. Manure and compost were applied by hand to plots and disked-in within two days after application. Soil samples were collected from all plots each year after corn harvest and before manure or compost application. Surface soil (0 to 6 inches) samples collected in 1996 were air dried, ground to pass 1-mm mesh, and analyzed for pH (1:1 soil to water ratio) to evaluate effects of manure, compost, and fertilizer application on soil acidity. The University of Nebraska Soil and Plant Analysis

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Laboratory using the standard test determined calcium carbonate concentration of manure and compost.

Least significant difference based on an analysis of variance was used to determine differences among treatments. A probability level ≤ 0.10 was considered significant.

Results

The manure and composted manure used in this study were collected from feedlot pens at the University of Nebraska Agricultural Research Center near Mead, Neb. The rations used in these pens seemed to contain less limestone than those usually used in commercial feedlots (usually about 2%-4% calcium carbonate). Manure collected from six feedlots across Nebraska contained 2.3% to 4.0% calcium carbonate (dry weight basis) while manure and compost used in our study contained < 1.4% calcium carbonate. Although, some of this calcium carbonate ($CaCO_3$) may come from the soil mixed with manure and scrapped from the feedlots, most is likely from feces. The $CaCO_3$ contents of beef cattle feedlot manure and composted manure used in our study (Table 1) were lower than the manure collected from commercial feedlots. The $CaCO_3$ amounts added with manure and compost ranged from 330 to 1,550 lb per acre (Table 2) indicating excellent liming potential of these organic resources when applied to low pH soils. When manure from commercial feedlots is used, one-time N-based manure or compost application may provide half of the lime required for a soil with a Woodruff buffer pH of 6.7 and 25% of the lime required for a soil with a Woodruff buffer pH of 6.5.

Applications of ammonium nitrate and diammonium phosphate for four years significantly decreased soil pH from 6.2 in 1992 to 5.6 in 1996 (Table 3). Phosphorus-based manure and compost applications also received additional N as ammonium nitrate fertilizer, but the lime applied with manure and compost maintained the soil pH level at the original 1992 level. Nitrogen-based manure and compost applications increased the soil pH as compared with the unfertilized check or the P-based application. Nitrogen or P-based manure or compost application resulted in significantly higher soil pH than fertilizer application. Biennial manure or compost application resulted in similar soil pH as annual application (Table 3). Soil pH was significantly related to the amount of manure and compost $CaCO_3$ applied (Figure 1). The relationship clearly indicates good correlation between the amounts of $CaCO_3$ applied and increases in soil pH. The soil in this study would not typically require lime addition, but the use of NH_4-based N fertilizers (especially anhydrous ammonia which is commonly used) can decrease soil pH to a level where lime application is recommended.

Liming materials passing through 60 mesh (60 openings per inch) sieve is considered 100% effective. Since lime in manure has passed through the digestive system of the animals it should be in

Table 1. Characteristics of beef cattle feedlot manure and composted feedlot manure applied in four years at Mead, Neb. All parameters are on dry weight basis.

Year and Source	Total Carbon	Total N	NH_4-N	Total P	$CaCO_3$
	%				
1992					
Manure	7.84	0.79	0.126	0.23	0.84
Compost	9.50	1.10	0.017	0.42	1.24
1993					
Manure	13.31	1.02	0.048	0.50	1.37
Compost	8.74	0.77	0.003	0.32	0.70
1994					
Manure	23.70	1.56	0.037	0.33	0.66
Compost	7.35	0.76	0.006	0.41	1.16
1995					
Manure	17.28	1.30	0.090	0.32	0.42
Compost	6.82	0.78	0.010	0.31	0.62

Table 2. Amounts of dry weight of composted or uncomposted beef cattle feedlot manure and calcium carbonate applied to soil in four years at Mead, Neb.

	Dry weight				$CaCO_3$				
Treatment	1992	1993	1994	1995	1992	1993	1994	1995	Total
	ton per acre				lb per acre				
Manure for N	21	8	5	6	352	226	71	54	703
Manure for P	13	3	3	1.2	212	78	38	10	338
Manure for N/2 y[a]	42	0	16	0	706	0	213	0	919
Manure for P/2 y	25	0	9	0	424	0	116	0	540
Compost for N	15	22	11	16	381	310	261	201	1153
Compost for P	7	4	2	1.3	170	64	78	16	328
Compost for N/2 y	31	0	34	0	765	0	781	0	1546
Compost for P/2 y	14	0	7	0	342	0	232	0	574
Fertilizer	—	—	—	—	0	0	0	0	0
Untreated check	0	0	0	0	0	0	0	0	0

[a]2 y indicates biennial manure or compost application.

Table 3. Surface soil (0-6 inch) pH after four years of composted and uncomposted beef cattle feedlot manure application at Mead, Neb.

Treatment[a]	pH[b]
Manure for N	6.53 de
Manure for P	6.15 g
Manure for N/2 y	6.52 de
Manure for P/2 y	6.26 fg
Compost for N	6.72 c
Compost for P	6.12 g
Compost for N/2 y	6.68 cd
Compost for P/2 y	6.19 g
Fertilizer	5.62 h
Untreated check	6.39 fe
$LSD_{0.10}$	*0.19*

[a]P-based treatments also received N fertilizer as broadcast and incorporated ammonium nitrate. 2 y indicates biennial manure or compost application.
[b]The initial surface (0-6 inch) soil pH of the field was 6.20.
[c,d,e,f,g,h]The values followed by the same letter are not significantly different based on least significant difference ($P = 0.10$).

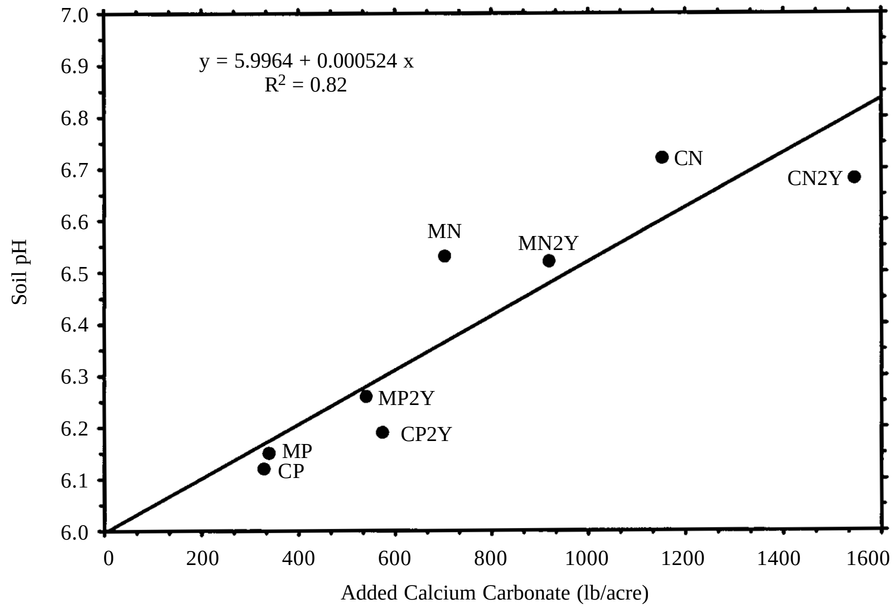

Figure 1. Effect of application of calcium carbonate in cattle feedlot manure or composted manure for four years on surface soil (0 to 6 inch) pH. Fertilized and unfertilized soils had pH of 5.62 and 6.39, respectively. CN is N-based compost, CP is P-based compost, MN is N-based manure, MP is P-based manure, and 2y is biennial application.

Table 4. Lime needed to bring soil pH to 6.5 according to Woodruff and SMP lime requirement tests[a].

Buffer pH	Woodruff		SMP	
	6.67[b]	8.0	6.67	8.0
	lb/acre		lb/acre	
6.9	1,000	1,200	—	—
6.8	2,000	2,400	2,000	2,400
6.7	3,000	3,600	3,500	4,200
6.6	4,000	4,800	4,800	5,800
6.5	5,000	6,000	6,000	7,400
6.4	6,000	7,200	7,800	9,400
6.3	7,000	8,400	9,200	11,000
6.2	8,000	9,600	10,700	12,800
6.1	9,000	10,800	12,000	14,400
6.0	10,000	12,000	13,500	16,200

[a]Data taken from D. Knudsen.1982. How much lime to use. Soil Science News, University of Nebraska Extension.
[b]Depth (inch) of incorporation of lime in soil

very small sizes and can be considered 100% effective. Manure and composted manure should be tested for calcium carbonate content and used similar to commercial lime on acid soils according to the University of Nebraska recommendation. The amounts of lime to apply to raise the soil pH to 6.5 are given in Table 4.

Conclusions

Manure and composted manure usually contain significant amounts of calcium carbonate and can contribute to liming reaction in fields with low soil pH. All or a fraction of the recommended amount of lime may be added when beef cattle feedlot manure or composted manure are applied based on N requirements of corn. Phosphorus-based manure and compost applications, with additional N as ammonium nitrate, maintained soil pH near its original level. Nitrogen-based applications of manure and compost resulted in higher soil pH than P-based applications. A P-based manure and compost application strategy, which needs to be used in sites vulnerable to P runoff losses, was not as effective as a N-based strategy for increasing soil pH. Biennial manure or compost application resulted in similar soil pH as annual application. Four years of inorganic N fertilizer (ammonium nitrate and diammonium phosphate) application significantly reduced soil pH relative to the initial level. Manure or compost from beef cattle feedlots can be good sources of lime.

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Effect of Sawdust or Acid Application to Pen Surfaces on Nitrogen Losses from Open-Dirt Feedlots

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Applying sawdust to increase carbon on pen surface led to more nitrogen in manure and reduced nitrogen loss without affecting performance.

Summary

Two nutrient management treatments (sawdust or sulfuric acid application to pen surface) were compared to conventional management using 12 pens (10 steers/pen) to determine effects on performance and nitrogen losses from pens. Performance and carcass characteristics for treatments were similar to the control. The sawdust treatment retained more nitrogen in manure when removed from the pen surface and after composting. Increasing carbon by sawdust additions reduced nitrogen losses by 21%. Applying acid to the pen surface did not affect quantity of nitrogen or organic carbon conserved in manure and compost.

Introduction

Nitrogen is lost from the feedlot surface and during manure handling through volatilization. This nitrogen loss reduces the amount of nitrogen available to crops when manure is used as a fertilizer source. Plants require a nitrogen:phosphorus (N:P) ratio of 5:1 or greater; however, after substantial nitrogen loss the N:P ratio of feedlot manure is 2:1 or less.

Adding an additional source of carbon may improve the nitrogen retaining properties of the manure on the pen surface and during composting. The addition of a carbon source, such as sawdust, widens the carbon:nitrogen (C:N) ratio of the manure. As the C:N ratio becomes greater, there is a tendency to retain more nitrogen.

The majority of nitrogen lost from feedlot manure is through volatilization. The pH where ammonia (form of nitrogen leading to volatilization) volatilization is greatest occurs above pH 9. Reducing pH below 5 can nearly eliminate ammonia loss.

The objective of this research was to examine the effectiveness of adding sawdust as a carbon source and lowering pen surface pH with sulfuric acid on nitrogen losses from feedlot manure and effects on cattle performance.

Procedure

One-hundred twenty yearling steers (672 $\pm$ 67 lb) were fed through the summer months for 132 days beginning June 14 and ending Oct. 16, 1995. Steers were initially implanted with Revalor-S and were randomly assigned to one of three treatments (10 steers/pen; four pens/treatment). Treatments were control, sawdust bedding application to pen surface and acidification of pen surface with sulfuric acid.

All treatments were fed the same diet formulated for 12% crude protein. Diet contained 80% dry-rolled corn, 10% alfalfa hay, 5% molasses and 5% supplement. Initial weights were an average of weights taken on two consecutive days following a five-day limit-feeding period. At slaughter, hot carcass weights were taken. USDA Quality grade and fat depth measured at 12th rib were recorded after a 24-hour chill. Final weights were calculated as hot carcass weight divided by a common dressing percentage (62).

Steers were fed in 12 open-dirt pens with a pen density of 273 ft^2/steer. Initial soil samples were taken to determine nitrogen and organic carbon percentage and pH. A pretest of experimental methods was performed to determine appropriate acid type and application rates, as well as amount of sawdust to be applied to the pen surface.

Before steers were introduced, the acid treatment pens were treated with sulfuric acid to initiate a pen surface between pH 4.5 and 5.5. Surface pH was monitored three to four times per week using one soil sample taken from four locations within each pen. Sulfuric acid was applied twice per week to regions of pens that measured above pH 5.5. An average of 1.3 moles/ft^2 (1 mol/L) was applied throughout the trial using a hand-held sprayer.

Sawdust by-product from a wood mill was added twice weekly to provide a 2:1 ratio of sawdust to fecal dry matter. Four-hundred sixty-five pounds of sawdust dry matter were added to pens each week. Sawdust was spread throughout the entire surface of each pen in the treatment at a rate of 0.17 lb/ft^2.

After steers were removed from pens, manure was scraped from the pen surface. Thirty manure samples were taken from each pen, and remaining manure was loaded onto trucks. An as-is weight was then taken and manure was hauled to a composting site. The manure was allowed to compost, and samples were taken after the composting process.

Manure and compost samples were frozen until analyzed at -20°C. Gravimetric water content was determined by drying for 24 hours at 105°C. Samples were analyzed for total nitrogen, ammonium (NH_4-N), nitrate (NO_3-N) and organic carbon content. Ammonium and NO_3-N analysis was conducted on moist samples while all other analysis was performed on air-dry samples.

Nitrogen intake (lb/steer) was calcu-

Table 1. Nitrogen balance.

Item	Treatment			P-Value	LSD[a]
	Control	Acid	Sawdust		
N intake, lb/steer	62.4	61.7	61.8	0.52	2.4
N retention, lb/steer[b]	7.3	7.3	7.3	0.84	0.2
N excretion, lb/steer[c]	54.4	54.5	55.2	0.72	2.4
Manure N, lb/steer	12.2	13.6	21.7	<0.01	3.5
N lost, lb/steer[d]	42.2	38.9	33.5	—	—
Compost N, lb/steer[e]	7.5	8.7	14.6	< 0.01	2.2
Organic carbon, lb/steer[f]	142	156	366	—	—

[a]Least Significant Difference (P=0.05).
[b]Determined using net protein gain equation (NRC,1996).
[c]Calculated as N intake minus N retention.
[d]Calculated as N excretion (lb/steer) minus manure N (lb/steer).
[e]Amount of N in compost, measured with ash as a marker of organic matter disappearance.
[f]Determined by laboratory analysis.

Table 2.Nitrogen and organic carbon content of manure removed from feedlot pens and final compost product expressed in dry matter.

Item	Treatment			P-Value	LSD[a]
	Control	Acid	Sawdust		
Manure					
Manure wt., lb DM/steer	885	958	1795	<0.01	280
Total N, %	1.45	1.43	1.21	0.14	—
NO_3-N, ppm	34	23	80	<0.01	22
NH_4-N, ppm	685	1664	765	<0.01	449
Compost					
N, %1.10	1.21	1.03	0.6	—	
Organic carbon, %	8.6	10.1	14.60	.07	5.2

[a]Least Significant Difference (P=0.05).

lated as concentration in diet multiplied by dry matter offered minus nitrogen in feed refused times dry matter feed refused. Nitrogen retention (lb/steer) was calculated by using the net protein gain equation (NRC,1996). Nitrogen excretion (lb/steer) was calculated as nitrogen intake minus nitrogen retention. Nitrogen loss (lb/steer) was determined as nitrogen excretion (lb/steer) minus manure nitrogen (lb/steer). Amount of nitrogen in compost was measured with ash as a marker of organic matter disappearance.

Results

Yearling performance

In this trial, there were no statistical differences (P<0.10) between treatments in ADG (3.66 lb.), feed conversion (6.41) or hot carcass weight (727 lb.). The cattle on the sawdust bedding treatment showed a slight decrease in fat depth (0.40 vs 0.48 in.) and USDA quality grade (17.8 vs 18.4, where 17=S° and 18=S$^+$) compared to the other two treatments.

Manure nutrient data

Total manure weight removed in sawdust treatment was two times greater than acid or control treatments. The sawdust treatment resulted in the most nitrogen (21.7 vs 12.2 control or 13.6 acid, lb N/steer) being removed from the pen surface in manure (Table 1). Sawdust treatment reduced nitrogen loss by 21% compared to the control (Table 1). In previous reports (*2000 Nebraska Beef Report*, pp. 65-67), <5% of all nitrogen excreted is lost through runoff, therefore it is hypothesized that most of the nitrogen lost during this trial was through volatilization. Adding sawdust as a carbon source to the pen surface resulted in the most pounds of manure dry matter and the highest concentration of organic carbon. Nitrate concentrations were highest in sawdust treatment (Table 2) implying aerobic conditions were increased over other treatments.

Pens treated with acid had an average surface pH of 5.4, while sawdust and control pens were 8.0 and 8.2, respectively. Applying an acid treatment was not effective in reducing the amount of ammonia volatilized or in increasing organic carbon concentration removed in manure above the control treatment. One explanation as to why nitrogen loss was unaffected is urea (primary form of nitrogen in urine) raised pH for short times at certain locations within the pen. Some nitrogen may be unaccounted for in runoff.

Compost nutrient data

Composting reduced nitrogen concentration of all treatments by 25% with no effect of treatment on nitrogen concentration loss (Table 2). The sawdust treatment lost the least amount of nitrogen per pound of nitrogen composted, but lost the most nitrogen in terms of total pounds, because it contained the most nitrogen initially. The sawdust treatment continued to contain the most organic carbon compared to control and acid treatments.

In this feedlot trial, sawdust applied to the pen surface allowed increased nitrogen retention over the acid and control treatments. However, reducing pen surface pH to 5 did not affect performance and carcass characteristics or nitrogen and organic carbon retention compared to the control. Using sawdust as a bedding could be one way to help reduce nitrogen losses from open-dirt feedlot pens.

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