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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

(Continued on next page)

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).

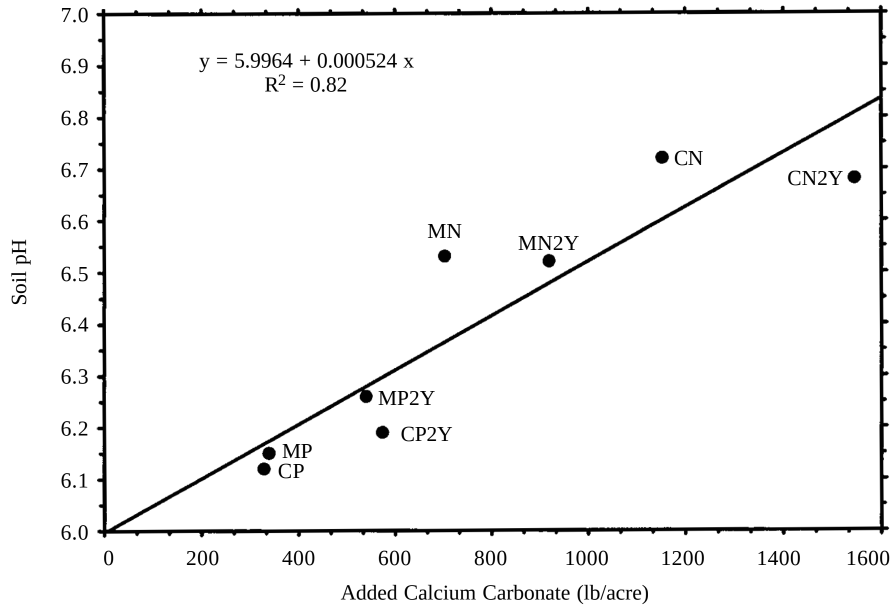

Figure 1. Effect of application of calcium carbonate in cattle feedlot manure or composted manure for four years on surface soil (0 to 6 inch) pH. Fertilized and unfertilized soils had pH of 5.62 and 6.39, respectively. CN is N-based compost, CP is P-based compost, MN is N-based manure, MP is P-based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