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Phosphorus and Nitrogen-Based Beef Cattle Manure or Compost Application to Corn

Bahman Eghball[1]

Nitrogen and phosphorus-based manure and compost applications resulted in similar corn yields across four years but soil P accumulation was much greater for N-based than P-based application.

Summary

This study was conducted to evaluate effects of P and N-based manure and compost applications on corn yield and soil P level. Annual or biennial manure or compost application resulted in corn grain yields similar to those with chemical fertilizer application. P-based manure or compost application resulted in similar corn grain yield but significantly less soil P build-up than N-based treatments. Estimated N availability was 40% for manure and 15% for compost in the first year and was 18% for manure and 8% for compost in the second year after application.

Introduction

Beef cattle feeding is concentrated in the Central and Southern Great Plains. At any one time, there are at least 10 million head of beef cattle on feed in the United States. Approximately 585,000 tons of N, 173,000 tons of P and 530,000 tons of K are excreted annually in this beef feedlot manure. Carbon in manure is likely to have far greater value than the nutrients it contains if applied to a low organic matter or eroded soil.

Composting manure is a useful method of producing a stabilized product that can be stored or spread with little odor, weed seeds, pathogens, or fly breeding potential. Composting also has some disadvantages. Study conducted by the author indicated 20-40% loss of total N and 46-62% loss of total C during composting of beef cattle feedlot manure, as well as significant losses of K and Na (> 6.5% of total K and Na) in runoff from composting windrows during rainfall.

Manure or compost application to provide for corn N requirements may greatly increase soil levels of P since the N:P ratios of beef cattle feedlot manure and composted manure are significantly smaller than N:P uptake ratios of most crops. The N:P ratio for feedlot manure is about 2.5 and is 2 for composted manure while N:P grain uptake ratios of winter wheat, corn, and grain sorghum are around 4.5, 5.9, and 4.5, respectively. The increase in soil P level can increase P loss in runoff, which has been associated with eutrophication (algae bloom and oxygen depletion) of rivers and lakes. The objective of this study was to evaluate the effects of application frequency and N and P-based rates of manure and compost application on corn grain yield and soil P level.

Procedure

A dryland experiment was initiated in 1992 on a Sharpsburg silty clay loam soil under dryland conditions at the University of Nebraska Agricultural Research Center near Mead, Neb. The study area had a Bray and Kurtz No.1 soil P test of 69 ppm, which is considered very high in Nebraska, and a pH of

Table 1. Characteristics of beef cattle feedlot manure and composted feedlot manure applied in four years at Mead, NE. Nutrients and ash contents are on dry weight basis.

Year and source	Total N	Total P	Ash	Water content	NO_3-N	NH_4-N	EC†	pH†
	%				ppm		m mho/cm	
1992								
Manure	0.79	0.23	84.4	19.5	30	1263	4.6	7.3
Compost	1.10	0.42	80.8	33.2	117	169	7.4	7.7
1993								
Manure	1.02	0.50	71.5	53.9	17	480	5.2	8.8
Compost	0.77	0.32	79.6	40.3	38	33	2.2	8.3
1994								
Manure	1.56	0.33	59.1	20.0	11	365	5.4	8.2
Compost	0.76	0.41	84.9	34.0	383	55	6.1	7.2
1995								
Manure	1.30	0.32	67.7	25.1	130	898	3.8	7.3
Compost	0.78	0.31	79.8	15.0	294	97	6.0	7.7

†Electrical conductivity (EC) and pH were determined on 2:1 water to dry manure or compost ratio.

Table 2. Composted and non-composted manure dry weight application in four years at Mead, Neb.

Treatment	Dry weight 1992	1993	1994	1995
	tons/acre			
Manure for N	20.9	8.3	5.4	6.5
Manure for P	12.6	2.9	2.9	1.2
Manure for N / 2Y†	41.9	—	16.2	—
Manure for P / 2Y	25.2	—	8.8	—
Compost for N	15.4	22.1	11.2	16.2
Compost for P	6.9	4.6	2.4	1.3
Compost for N / 2Y	31.0	—	33.6	—
Compost for P / 2Y	13.8	—	7.1	—
Fertilizer	—	—	—	—

†2Y indicates biennial manure or compost application.

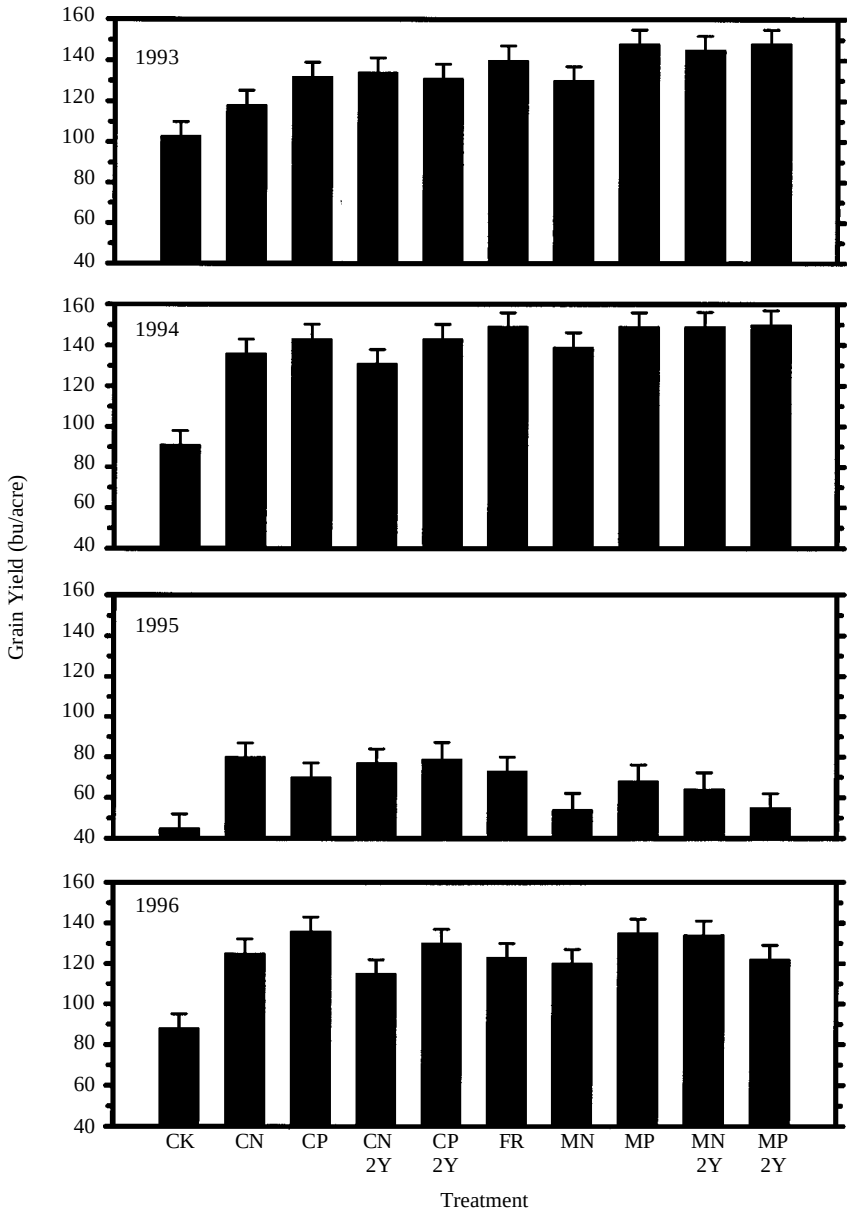

Figure 1. Corn grain yield for ten treatments in four years at Mead, Neb. Each vertical bar is standard deviation of that mean. CN is N-based compost, CP is P-based compost, MN is N-based manure, MP is P-based manure, FR is fertilizer, CK is check, and 2Y indicates biennial application.

6.2 in the top 6 inches. The experimental design was a randomized complete block with four replications. The 10 treatments applied included annual or biennial manure or compost application based on N or P removal of corn (135 lb N/acre and 53 lb P_2O_5/acre for an expected yield level of 150 bu/acre) and fertilized and unfertilized checks. Fertilizer application was made in the spring each year. If necessary, the P-based treatments (annual or biennial application) also received N fertilizer as ammonium nitrate (34-0-0, N-P-K) in the spring so that a total of 135 lb N/acre was available to the crop.

Beef cattle feedlot manure (collected in November) and composted feedlot manure were applied in November 1992 based on the assumption that 40, 20, 10 and 5% of the N and P in manure or compost will become plant available 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, 5% in the first, second, third and fourth year after compost applications in 1993, 1994 and 1995. Biennial manure or compost applications were made to provide 135 lb N/acre for N-based and 53 lb P_2O_5/acre for P-based rates in the second year after application based on the assumptions given above. Residual N and P values from previous years were considered when manure or compost were applied.

Manure or compost application was made in late autumn (November or December) after corn harvest. Manure and compost were applied by hand to plots 40 feet long and 15 feet wide (six corn rows). The characteristics and amounts of manure and compost applied for each treatment are given in Tables 1 and 2. Manure and compost were applied and disked-in within two days after application. Corn (Pioneer 3394) was planted at a seeding rate of 19,000 seeds/acre and a row spacing of 30 inches. The planting dates were May 21, 1993, May 10, 1994, May 24, 1995, and May 21, 1996. Corn was harvested by hand in October (middle 2 rows, 20 feet long) of each year and grain yield determined. The reported yields are adjusted to 15.5% moisture content.

Soil samples were collected from all plots each year after harvest. The surface soil (0 to 6 inches) samples were analyzed for Bray and Kurtz No.1 soil P test to evaluate the effects of manure, compost and fertilizer application on the soil P level. The amounts of rainfall from June 1 to Aug. 31 for the above years were 23.4, 15.9, 4.2, and 8.5 inches for 1993, 1994, 1995 and 1996, respectively.

Results

Grain yield

There was a significant year by treatment interaction for corn grain yield. The relative differences among treatments were different for each year (Figure 1). Grain yields for all treatments were greater than the check. Grain yields for the manure and compost treatments were similar to those for the fertilizer treatment in all four years (Figure 1). This indicates that annual or biennial

(Continued on next page)

manure or compost application can provide added nutrients to corn, similar to fertilizer application, with added benefits of organic matter and micronutrients addition to the soil. Phosphorus-based manure or compost application, with additional N as fertilizer, produced similar corn grain yields to those for the N-based and fertilizer treatments.

Nitrogen use efficiency was greater for manure than compost application. The estimated first-year N availability from manure N was 40%, and was 15% for compost application. Second-year N availability estimation was 18% for manure and 8% for compost application. Nitrogen availability from compost was less than the expected 20%. Small fractions of N are available in the third and fourth year after application (usually <10%). The manure or compost N remaining after the fourth year become a portion of soil-N and a small fraction becomes plant available each year.

Soil Phosphorus

The results indicate that surface soil (top 6 inches) phosphorus level was greatest for the biennial N-based compost application and was least for the check plot (Figure 2). There was a significant year by treatment interaction for soil P level. Soil P levels for all N-based treatments were greater than those for the check plots (Figure 2). Annual P-based manure and compost application had P levels that were similar to the original soil P level of 69 ppm even after four years of manure and compost application.

Even though the N-based manure and compost treatments had soil P levels similar to those for the fertilizer treatment in 1993, they had higher soil P levels than the fertilizer treatment in later years (Figure 2). Biennial P-based manure or compost application resulted in greater soil P build-up than did annual P-based manure or compost applicature. This is because of the greater amount of manure or compost applied every other year. Nitrogen-based manure or compost application resulted in available soil P levels that were significantly greater than those for the P-based manure or compost application, fertilizer, or check treatments. After four years of application, annual P-based manure or compost treatments had soil P levels similar to the original soil P level before treatment application.

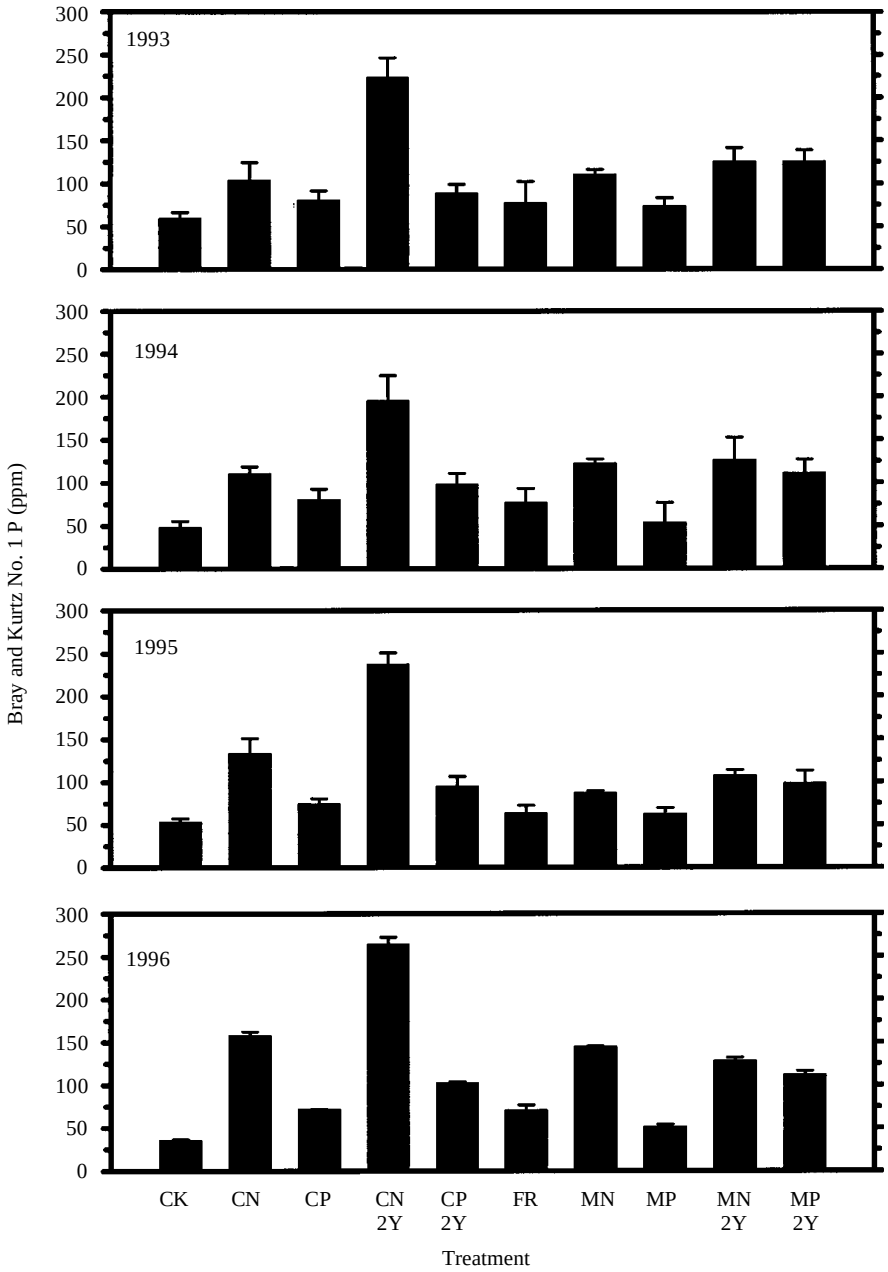

Figure 2. Surface soil (0-6 in) P levels for ten treatments in four years at Mead, Neb. Each vertical bar is standard deviation of that mean. CN is N-based compost, CP is P-based compost, MN is N-based manure, MP is P-based manure, FR is fertilizer, CK is the check, and 2Y indicates biennial application.

Phosphorus-based manure or compost application strategy can increase the distance manure and compost need to be hauled and hence increase the application cost. Therefore, P-based application should be used in sites vulnerable to P runoff losses. A recently developed P Risk Assessment Index can be used to determine which sites are vulnerable to P runoff losses. Nitrogen-based manure and compost applications can be used in areas where the potential for P runoff loss is minimal.

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