Impact of Manure Application on Phosphorus in Surface Runoff and Soil Erosion

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Reducing P in feedlot diets has long-term impacts in reducing P contamination of surface water from runoff and erosion on manure amended soil.

Summary

Effects of method of manure management and dietary P were compared on 21 natural runoff plots to monitor the long-term impact of dietary P to P losses in runoff and erosion. Reducing feed P resulted in a 33% reduction in manure P content and soil test P buildup and runoff losses of P also were directly proportional to feed P inputs. The timing and management of manure are also important considerations for controlling P losses in runoff in the year of application. However, residual effects of timing and management are probably small. Management criteria designed to assess the potential for landscape P-loading (i.e. "P-index") correctly weight winter applications as more detrimental than planting time applications.

Introduction

Phosphorus (P) losses from agricultural land is a serious environmental issue because of the impact of P on freshwater eutrophication. The movement of P from soil to surface water is impacted by P input to soil and manure management practices that impact P transport processes. Previous research has shown that the nutritional requirement for P is quite low and added inorganic P to corn-based feedlot diets has no value (*1998 Nebraska Beef Report,* pp. 78-80; *2002 Nebraska Beef Report,* pp. 45-48). Our study was designed to monitor the long-term effects of dietary P inputs and manure management on P losses to the environment.

Procedure

Twenty-one natural runoff plots (0.01 acre ea.) were established on an irrigated Sharpsburg silty clay loam soil in 1998 to monitor the effects of manure application time as well as the long-term impact of reducing P in beef feedlot rations on P losses in runoff and sediment. Average soil slope was 6.2%. Compost was generated from feedlot manure and nutrition studies conducted at the Agricultural Research and Development Center research feedlot. Compost from 1998 and 1999 was from the same study, evaluating conventional dietary P levels (0.35% of diet DM) compared to diets without supplemental mineral P (0.25%P). Performance data and nutrient balance in the feedlot were published previously (*2000 Nebraska Beef Report* pp. 65-67). Decreasing dietary P decreased the amount that was removed in manure.

Annual compost applications were made at a rate to meet the N needs of the corn crop (178 lb N/acre) assuming 30 % mineralization of organic N each year. Compost was applied with three method/time treatments in a randomized complete block design with 3 replications to evaluate the effect of management on P losses in runoff. A replicated control consisting of 178 lb N/acre applied as NH_4NO_3 broadcast incorporated prior to spring planting was also included (Table 1). Plots were disked once so that

Table 1. Treatment schematic outlining composted manure treatments applied from June 1998 to January of 2001.

Treatment	P level	Application method	Application time	Dates of application
H-Sp-I	High-P	Incorporated	Spring-preplant	April 1998, 1999, 2000
H-Sp-S	High-P	Surface applied	Spring-postplant	May 1998, 1999, 2000
H-W	High-P	Surface applied	Winter	January 1999, 2000, 2001
L-Sp-I	Low-P	Incorporated	Spring-preplant	April 1998, 1999, 2000
L-Sp-S	Low-P	Surface applied	Spring-postplant	May 1998, 1999, 2000
L-W	Low-P	Surface applied	Winter	January 1999, 2000, 2001
N fertilizer	none	Incorporated	Spring-preplant	April 1998, 1999, 2000

Table 2. Compost characteristics and application rates.

Compost Type	Year	Total N %	Total P %	N:P	Compost rate[a] ton/acre		Applied P lb/acre
High - P	1998	0.81	0.36	2.3:1	37		266
	1999	0.80	0.43	1.9:1	37		319
	2000	0.64	0.46	1.4:1	46		435
						Total:	1020
Low - P	1998	0.81	0.28	2.9:1	37		207
	1999	0.79	0.36	2.2:1	37		270
	2000	0.60	0.20	3.0:1	50		198
						Total	675

[a]Compost rate to deliver 178 lb N/acre assuming 30% mineralization rate of organic N.

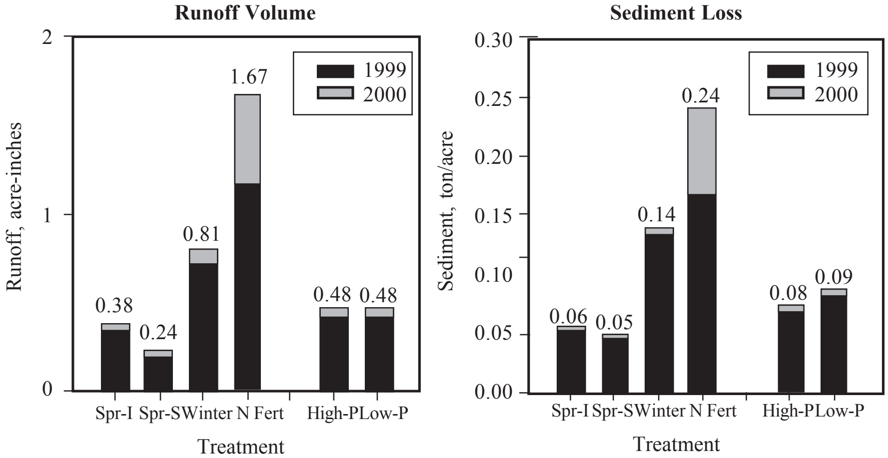

Figure 1. Annual runoff and sediment losses by treatment during compost application years.

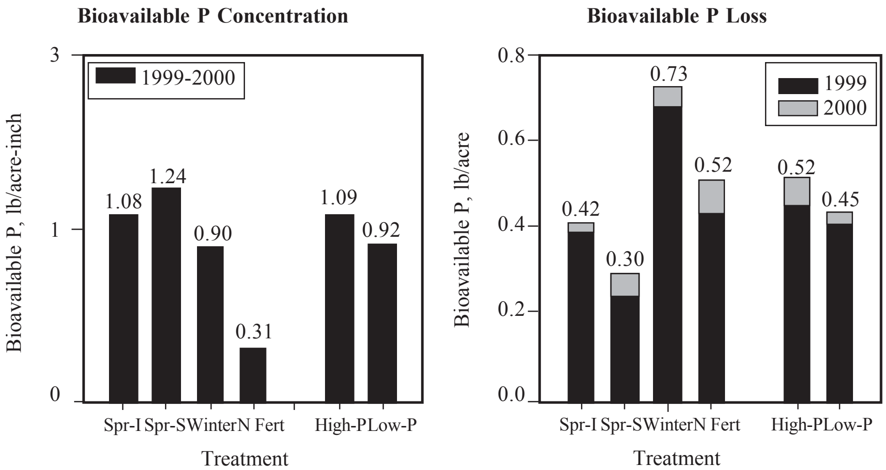

Figure 2. Average bioavailable P (BAP) concentration and annual BAP losses, by treatment, during compost application years.

the winter (W) and spring incorporated (Sp-I) treatments were incorporated prior to planting.

Three consecutive annual applications of composted manure were made beginning in 1998 through 2000. The first winter application was made in January of 1999 and the last in January of 2001. Corn was planted at 26,000 plants/acre in 1999-2000. Soybean was planted at 137,000 plants/acre in 2001. No compost or fertilizer applications were made after January, 2001. Table 2 lists the compost N and P characteristics by year. Runoff collection was initiated in 1999 following natural precipitation events and analyzed in duplicate for volume, sediment concentration and bioavailable P (BAP).

Results

Animal Performance

Reducing dietary P from conventional levels (0.35% or greater) to diets with no supplemental P (0.25%) improved animal P use efficiency, decreased P excreted and did not affect animal performance. Erickson et al. (*1998 Nebraska Beef Report,* pp. 78-80; *2002 Nebraska Beef Report,* pp 45-48) concluded that typical grain finishing diets contain enough P for optimal gains.

Runoff, Sediment and P Losses

In this eastern Nebraska environment, runoff occurred only during the spring months (March–June) and only trace amounts of runoff were experienced in the fall. Results are shown for two distinct periods: a) compost application years (1999-2000), and b) residual year (2001) following three years of compost application.

In the years of compost application (1999-2000), time of application effect on compost weathering had a significant effect on runoff volume loss. We observed that a longer time interval between compost application date and spring runoff season resulted in a diminished effect on water retention. Runoff volume was not affected by compost type as rate of application did not differ between High-P and Low-P manures. Spring applications had the effect of decreasing runoff volume compared to winter application (Figure 1). In the residual year (2001), when no compost had been applied, runoff volume was about 2/3 of the no-compost control. Note that 2001 runoff volume from the 2001 winter application was lower than that from the spring 2000 application, because of the difference in the time of compost weathering between these treatments. The winter application in Figure 2 was applied almost eight months after the spring application.

Sediment losses in the years of application (1999-2000) were directly proportional to runoff volume. Although sediment concentrations were higher in the surface-applied treatments, decreased runoff volume reduced the total sediment load (Figure 1). In the residual year (2001) winter application of compost resulted in very high sediment concentration in runoff following a substantial winter runoff event when the soil surface soil was frozen. Sediment load was not impacted by compost type in 2001 (Figure 2).

Bioavailable P (BAP) losses in runoff were nearly proportional to P loading rates by compost type in both application and residual years of study. Phosphorus loading to soil as compost was 1.5 times greater for the High-P vs. the Low-P manure and BAP losses (total of all years) were 1.6 times greater from High-P vs. Low-P amended plots. More phosphorus as BAP was lost during the application years of 1999-2000 from the

(Continued on next page)

winter treatment compared to the spring-applied compost treatments (Figure 3). Most "P-indices" place a greater penalty on winter manure applications than those made at planting time. Our results confirm that the diminished runoff protection from winter applications because of weathering and the danger of runoff from frozen soil increases P loss to surface water. In the residual year (2001) compost application no longer had the effect of reducing runoff and so BAP losses were more than double that from the control. Application time no longer had the effect of reducing BAP losses in the residual year (2001) (Figure 4).

In summary, reduction in supplementary P inputs had a direct effect on P losses to surface water in runoff and sediment. We will be maintaining these runoff plots for the next several years to monitor the long-term residual effect of soil P loading on runoff, sediment and P losses to surface water.

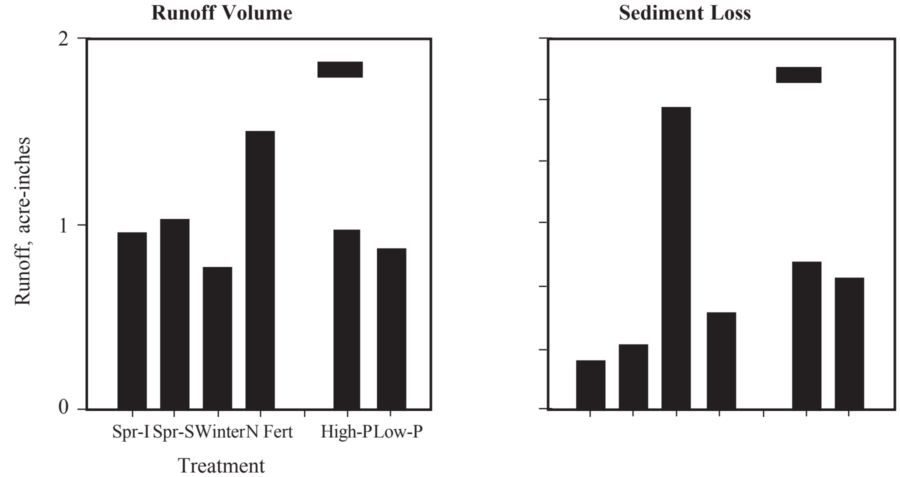

Figure 3. Annual runoff and sediment losses by treatment during residual post-application year.

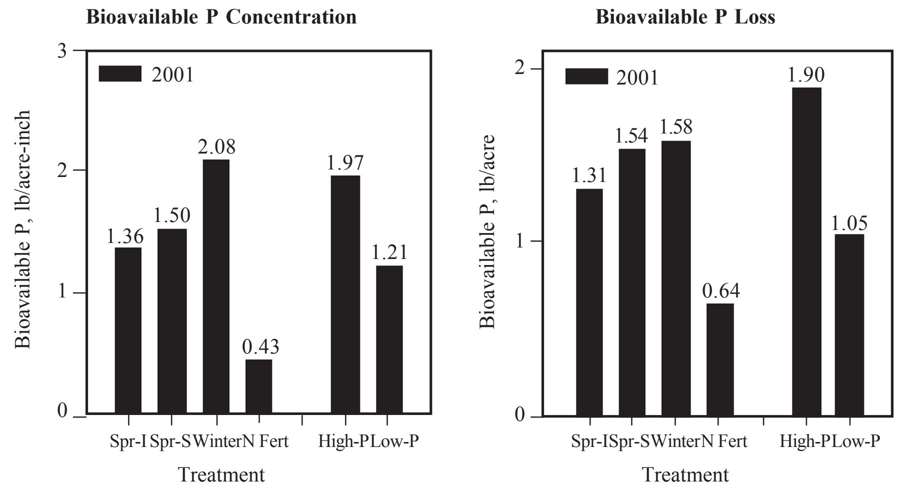

Figure 4. Average BAP concentration and annual BAP losses, by treatment, during residual post-application year.

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