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Fertilizer and Swine Manure Management Systems: Impacts on Agronomic and Environmental Soil Phosphorus Tests and on Phosphorus Loss with Subsurface Drainage

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Abstract
Manure or fertilizer can be used to supply the phosphorus (P) needs of crops. However, excess P application increases the risk of P loss from fields and of water quality impairment through increased algae growth. Poor water quality in many Iowa lakes has prompted questions about the impact of P management practices on P loss from fields and the effectiveness of using agronomic soil tests for environmental purposes.

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Introduction

Manure or fertilizer can be used to supply the phosphorus (P) needs of crops. However, excess P application increases the risk of P loss from fields and of water quality impairment through increased algae growth. Poor water quality in many Iowa lakes has prompted questions about the impact of P management practices on P loss from fields and the effectiveness of using agronomic soil tests for environmental purposes.

A study is being conducted at the Iowa State University Northeast Research Farm to assess the effects of fertilizer and liquid swine manure management for corn-soybean rotations on grain yield and nutrient loss with tile drainage. Treatment details and effects on yield and nitrogen (N) losses are described in the article "Fertilizer and Swine Manure Management Systems: Impacts on Crop Production and Nitrate-Nitrogen Leaching with Subsurface Drainage." This report summarizes P management effects on soil P and P loss. Briefly, treatments include the use of N and P fertilizer (two treatments with similar P rates but different N application methods), fall or spring N-based manure for corn, fall P-based manure for corn (plus N fertilizer as needed), and fall N-based manure for both crops. The P fertilizer (triple superphosphate) is incorporated into the soil by chisel plowing and disking, and the manure is injected.

Summary Results

The agronomic and environmental soil P tests measured different amounts of P (Table 1). All tests ranked the treatment similarly, which indicates that these tests were similar in evaluating the effect of fertilizer or manure applications on soil P. The N-based manure application increased soil P more than P-based fertilizer or manure applications. This result is explained by a lower N:P ratio in the manure compared with crop needs. Application of N-based manure rates for both crops of the rotation (System 4) resulted in the highest soil P values. The excess P applied with N-based manure rates also increased P in the 6–12 inch subsoil layer (Figure 1).

The yearly average P concentration in tile drainage was very low and was not related to the treatments. Less than 1/2 oz/acre of P_2O_5 was lost each year. This result agrees with the lack of treatment effects on subsoil P below a 1-foot depth. Plots with soil-test P four times the optimum level for crops lost as little P as plots testing near optimum. Optimum levels are 16–20 ppm for the Bray-1 or Mehlich-3 tests and 11–14 ppm for the Olsen test. The low P loss probably explained a lack of correlation between P in tile drainage and soil P measured by any test. As an example, Figure 2 shows the relationship between Bray-1 soil P and P concentration in tile drainage.

Conclusion

Nitrogen-based manure applications have increased soil-test P above optimum levels for crops, but did not increase P loss with tile drainage compared with P-based fertilizer or manure management. However, the study will continue because prolonged N-based manure applications will increase soil-test P further and may increase P loss.

Table 1. Treatment effects on yearly average P concentration in tile drainage water and P loss.

System	N and P management ‡	Spring 2002 soil-test P †						Yearly P in tile drainage			
								P concentration		P loss	
		BP	M3P	OP	BioP	WP	Psat	2001	2002	2001	2002
		----------- ppm ------------					%	------ ppb -----		oz P_2O_5/acre/year	
1	P fertilizer, spring N fertilizer	28	26	13	19	6	3.2	4	34	0.09	0.05
2	Fall manure for corn, N-based	52	52	32	42	16	6.5	9	28	0.20	0.25
3	Fall manure for corn, P-based	24	22	12	19	6	2.6	5	47	0.13	0.04
4	Fall manure, 2-crop N removal	80	89	52	73	28	9.4	6	17	0.22	0.04
5	P fertilizer, sidedress N fertilizer	24	22	13	18	6	2.8	4	16	0.14	0.09
6	Spring manure for corn, N-based	27	25	13	19	6	2.9	4	17	0.24	0.26

† BP, Bray-1; M3P, Mehlich-3; OP, Olsen; BioP, bioavailable P (iron-oxide impregnated paper test); WP, water extractable P; and Psat, P saturation (Mehlich-3 molar ratio test).

‡ The rates of P fertilizer and P-based manure are based on P removal (60 P_2O_5/acre for corn and 44 P_2O_5/acre for soybeans) and soil-test P. The N-based manure rates were equivalent to 150 lb N/acre for corn and, only in System 4, 200 lb N/acre for soybeans.

Fig. 1. Soil P Distribution with Depth for Six Nutrient Management Systems.

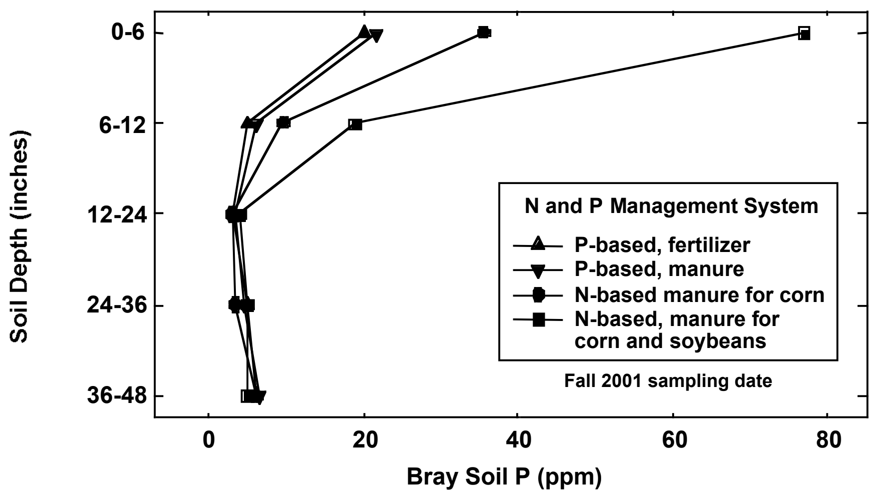

Fig. 2. Correlation Between Soil-Test P and P Concentration in Tile Water (2001 and 2002).