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Runoff Phosphorus Loss as Affected by Tillage, Fertilizer, and Swine Manure Phosphorus Management in Corn-Soybean Production Systems

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Abstract
Information on phosphorus (P) loss from surface runoff in fields managed with different cropping and P management systems is scarce. Swine manure can supply nitrogen (N), P, and K (potassium) for crops. Continued use of N-based manure rates can result in P buildup in the soil, mainly in continuous corn or when manure is applied for both corn and soybean production. Excessive soil P and P applications increase the risk of P loss from fields and of water quality impairment.

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Introduction

Information on phosphorus (P) loss from surface runoff in fields managed with different cropping and P management systems is scarce. Swine manure can supply nitrogen (N), P, and K (potassium) for crops. Continued use of N-based manure rates can result in P buildup in the soil, mainly in continuous corn or when manure is applied for both corn and soybean production. Excessive soil P and P applications increase the risk of P loss from fields and of water quality impairment.

A rainfall simulation technique was used to assess runoff P loss from a long-term trial comparing effects of fertilizer and liquid swine manure for corn-soybean rotations on grain yield and nutrient loss with tile drainage. Details of treatments, yields, and nutrient loss with tile drainage were summarized before. The systems used for this study are shown in Table 1. Rainfall was applied once in fall and spring seasons from 2002 to 2004 after tillage and treatment applications were completed. Two-year season averages are shown. Rainfall at 3 in./hour was simulated onto 33 ft^2 plots in areas with 3–5% slope. Runoff was analyzed for total P, bioavaliable P, and dissolved reactive P.

Summary Results

Treatment Effects on Soil P. Soil-test P (Bray-1) and total P were highest for the system using N-based manure for corn and soybean (Figure 1). It was intermediate for the two systems using N-based manure for corn, and lowest for the two systems using P-based fertilizer or manure for corn and P fertilizer for soybean.

Runoff P Concentrations. The management system, season, and crop residue affected the runoff P fractions in an approximately similar way, although total runoff P was much higher than for other fractions (Figure 2). Total runoff P includes dissolved P and P bound to soil particles. Dissolved P is easily transported long distances and has immediate effects on algae growth in streams and lakes. The P bound to soil particles can be transported short or long distances depending on the landscape form and water flow, and has a less immediate but long-term impact on algae growth.

Approximately similar system rankings for runoff P were observed in the fall and spring for corn residue: highest loss for N-based manure applied for both crops, intermediate loss with inconsistent differences for the three systems using P-based manure or fertilizer, and lowest for N-based spring manure for no-till corn.

The ranking between systems of runoff P from soybean residue differed for fall and spring seasons. In the fall, there was a very large runoff for the system using P fertilizer because of rain immediately after fertilizer application without incorporation or enough reaction time after fertilization. However, the probability of large runoff events in the fall is very low. The runoff P ranking for other systems was approximately similar to that observed for soybean residue in the spring and for corn in both seasons. Dissolved P concentrations in the spring, when runoff events are more likely in Iowa, were lowest (0.05–0.09 mg/L) for the system using P-based manure for corn and fertilizer P for soybean.

Runoff P Loads. System rankings for P loads are not shown because they usually followed similar trends in concentrations, but were more variable. All fractions of runoff P loss were much lower for the system using N-based manure for no-till corn, Iowa's long-term precipitation data indicates a low probability of surface runoff events in the fall, but a very high probability in the spring. Therefore, results for spring likely better represent the relative P loss differences between systems that may occur during the year under natural rainfall.

Conclusions

Application of N-based liquid swine manure for both crops of corn-soybean rotations resulted in large soil P buildup and the highest spring loss of dissolved, bioavailable, and total runoff P. Runoff P loss for systems using N-based manure rates for corn only were not consistently different from P loss for systems using P-based fertilizer or manure for corn and P fertilizer for soybean. No-till management reduced loss of all runoff P fractions.

Table 1. Nutrient management systems evaluated.

System and code	Residue	Tillage	P Applied
1. P-based fertilizer (Fert P)	Corn	CH-FC	Fall P fert
	Soybean	FC	Fall P fert
2. N-based manure for corn (M N-base)	Corn	CH-FC	None
	Soybean	FC	Fall manure
3. N-based manure for no-till corn (M N-base NT)	Corn	No-till	None
	Soybean	No-till	Spr. manure
4. P-based manure for corn (M P-base)	Corn	CH-FC	Fall P fert
	Soybean	FC	Fall manure
5. N-based manure for the two crops (M for 2 crops)	Corn	CH-FC	Fall manure
	Soybean	FC	Fall manure

Note: CH = fall chisel plowing,
FC = spring field cultivating

Fig. 1. Effect of the management systems on soil P

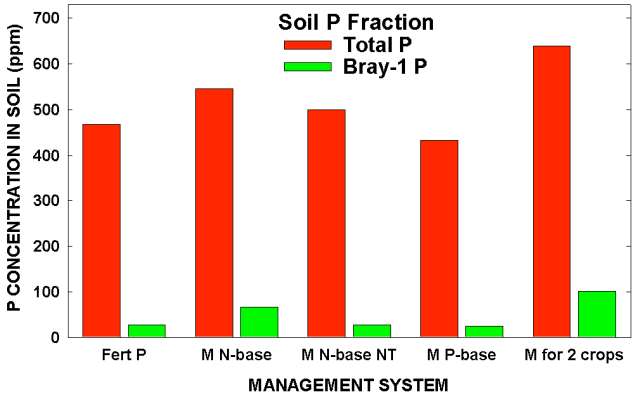

Fig. 2. Effect of management systems on runoff P concentrations