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Impacts of Phosphorus and Tillage Management Systems for Corn and Soybean Production on Soil and Phosphorus Loss with Surface Runoff—A New Long-Term Study

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Abstract
Excess sediment, phosphorus(P) and/or nitrogen (N) impair most Iowa lakes and many streams. Most of the sediment and nutrients originate from agricultural fields or stream banks. Previous research on P loss with surface runoff in the Northwest Iowa region was based on short-term rainfall simulations and included a limited set of conditions. The rainfall simulations provided useful information about potential differences between management practices but could not measure long-term differences or annual sediment and P loads. Very limited work has been conducted elsewhere in Iowa to study P loss with runoff based on natural rainfall and large-scale plots.

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Introduction

Excess sediment, phosphorus (P) and/or nitrogen (N) impair most Iowa lakes and many streams. Most of the sediment and nutrients originate from agricultural fields or stream banks. Previous research on P loss with surface runoff in the Northwest Iowa region was based on short-term rainfall simulations and included a limited set of conditions. The rainfall simulations provided useful information about potential differences between management practices but could not measure long-term differences or annual sediment and P loads. Very limited work has been conducted elsewhere in Iowa to study P loss with runoff based on natural rainfall and large-scale plots.

In-kind contributions from farmers of the Northwest Iowa Experimental Association and the Iowa State University Research and Demonstration Farms were used in spring 2006 to establish crop rotations and tillage management systems for a runoff P study. These contributions allowed for applying the nutrient treatments for the 2007 crop year and to install semi-automatic devices to collect surface runoff. Funding from the Integrated Farm/Livestock Management Demonstration Program of the Iowa Department of Agriculture and Land Stewardship were used to start collecting runoff samples in summer 2007 and to measure crop yields in fall 2007.

Specific objectives of the experiment were to study effects of corn and soybean production, tillage system, and P management systems based on fertilizer or liquid swine manure on 1) crop yields, 2) soil nutrient content, and 3) loss of sediment, dissolved P, and total P with surface runoff.

Materials and Methods

Five management systems were evaluated with three replications. Four systems involve corn-soybean rotations harvested for grain and one system involves continuous corn with harvest of grain and cornstalks. The two crops of the corn-soybean rotations are grown each year on randomized plots and the crops are switched over time. Therefore, the study includes 27 plots each measuring approximately 2,000 square feet. The five systems are the following:

1. Corn-soybean rotation managed with chisel-plow/disk tillage and fertilizer.
2. Corn-soybean rotation managed with no-tillage and fertilizer.
3. Corn-soybean rotation managed with chisel-plow/disk tillage and P-based liquid swine manure.
4. Corn-soybean rotation managed with no-tillage and P-based swine manure.
5. Continuous corn for grain plus cornstalk harvest managed with chisel-plow/disk tillage and N-based swine manure.

No fertilizer is applied for the continuous corn, and the liquid swine manure injected into the soil in the fall at 200 lb total N/acre each year supplies all nutrients. No fertilizer P is applied because the manure supplies P in excess of corn needs. The four corn-soybean rotation systems compare combinations of tillage treatments and fertilizer or manure P-based nutrient management. The P needed by the two crops of the rotation (based on soil testing and crop P

removal) is applied once before corn in the fall. For this year 100 lb P_2O_5/acre were applied because soil-test P was in the Optimum category. The P fertilizer (triple superphosphate) is broadcast and incorporated into the soil for the tilled systems and is not incorporated for the no-till system. The liquid swine manure (from an underground pit) is donated by a local producer and always is injected into the soil. Corn in the corn-soybean rotation systems receives fertilizer N (28% UAN solution injected in spring) as needed so that the total N applied (fertilizer, manure-N, or fertilizer plus manure-N) is at least 150 lb N and similar for the four systems. Potassium fertilizer and lime is applied uniformly across all plots. The corn hybrids are resistant to both rootworm and corn borer while the soybean variety is resistant to glyphosate and soybean cyst nematode.

Conclusions

This report summarizes only crop grain yields for the first year of the study because surface runoff samples collected during summer and fall are still being analyzed.

Table 1 shows that soybean yields were approximately similar for all systems, and analysis of variance indicated no statistical differences. Previous and ongoing research at this farm also has shown similar yields for soybean managed with no-till or chisel-plow tillage. Data for corn seem to suggest that yield was highest for System 1 (corn-soybean rotation managed with chisel-plow tillage and fertilizer P), lowest for System 5 (continuous corn managed with chisel-plow tillage and manure), and intermediate for all other systems. However, analysis of variance indicated that corn yields were similar for all four corn-soybean rotation systems and were higher than for the continuous corn. On average, the continuous corn yielded 10 bushels/acre less than the corn after soybean. Therefore, the yield results indicate that only crop rotation affected corn yield this year. These yield results should be interpreted with much caution, however, because this was only the second year in which the crop rotations were applied.

We plan to continue this study in the future as long as funding is available in order to collect crop, soil, and surface runoff data over several years. This long-term study should result in information very useful to improve knowledge on effects of crop, soil, and nutrient management practices commonly used in the region on soil and water quality.

Table 1. Systems effects on crop yield.[†]

Crop	Rotation	System	Tillage	Nutrient	Yield
					bu/acre
C	C-S	1	Chisel	Fertilizer P	184
C	C-S	2	No-till	Fertilizer P	180
C	C-S	3	Chisel	Manure P	177
C	C-S	4	No-till	Manure P	177
C	C-C	5	Chisel	Manure N	169
S	C-S	1	Chisel	Fertilizer P	56.7
S	C-S	2	No-till	Fertilizer P	55.0
S	C-S	3	Chisel	Manure P	55.0
S	C-S	4	No-till	Manure P	53.5

[†]C = corn; S = soybean.