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Corn Harvest and Nutrient Management Systems Impacts on Phosphorus Loss with Surface Runoff

Antonio P. Mallarino
Iowa State University, apmallar@iastate.edu

Aaron Alan Andrews
Iowa State University

Mazhar Ul Haq
Iowa State University, mazhar@iastate.edu

Matthew J. Helmers
Iowa State University, mhelmers@iastate.edu

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Abstract
Cellulosic biomass is being promoted for use in future bioenergy production systems as a better alternative to current grain-based systems. Cropping systems and partial or total corn biomass removal in addition to grain harvest changes crop P needs, crop residue, and P recycling. Both sediment and water losses may also be altered and these changes could result in increased P loss from fields. Livestock production results in the generation of large quantities of manure that is a valuable nutrient source for producing high biomass yield. Manure can be used to minimize use of inorganic fertilizers and enhance production efficiency. Therefore, this study evaluated the impacts of several crop and corn biomass harvest systems on P loss with surface runoff as affected by management based on fertilizers or liquid swine manure.

Keywords
RFR A9133, Agronomy, Agricultural and Biosystems Engineering

Disciplines
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Corn Harvest and Nutrient Management Systems Impacts on Phosphorus Loss with Surface Runoff

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Antonio Mallarino, professor
Aaron Andrews, graduate assistant
Mazhar Haq, assistant scientist
Department of Agronomy
Matt Helmers, associate professor
Department of Agricultural and Biosystems Engineering

Introduction
Cellulosic biomass is being promoted for use in future bioenergy production systems as a better alternative to current grain-based systems. Cropping systems and partial or total corn biomass removal in addition to grain harvest changes crop P needs, crop residue, and P recycling. Both sediment and water losses may also be altered and these changes could result in increased P loss from fields. Livestock production results in the generation of large quantities of manure that is a valuable nutrient source for producing high biomass yield. Manure can be used to minimize use of inorganic fertilizers and enhance production efficiency. Therefore, this study evaluated the impacts of several crop and corn biomass harvest systems on P loss with surface runoff as affected by management based on fertilizers or liquid swine manure.

Materials and Methods
A rainfall simulation technique was used on 0.05-acre plots of an ongoing field study at the Agriculture Engineering/Agronomy Research Farm. The soil was Clarion loam with 2 to 3% slope. Treatments replicated three times were continuous corn (CC) harvested for total biomass (CCTot), grain (CCGr), or grain plus baling a fraction of stover (CCSt); corn-soybean rotation harvested for grain with the two crops being grown each year (CsGr and ScGr); and switchgrass (Sw) harvested for biomass in the fall. The fertilizer management system (F) applied triple superphosphate and urea-ammonium nitrate (UAN) at recommended rates in Iowa. Manure management systems (M) applied N-based liquid swine manure. Fertilizers and manure were incorporated into the soil in spring at rates of 150 lb/acre for corn after soybean and 200 lb/acre for continuous corn. Fertilizer P was applied only to plots testing 20 ppm or less (Bray-1 or Mehlich-3) in the fall (first year) or spring (second year). The manured switchgrass treatment involved a previous history of large applications but not during this study. We measured residue cover and soil P from depths of 0–2 and 2–6 inches. Rainfall was applied at 3 inches/hour to 30 sq-ft plots. Surface runoff was collected during 30 minutes, weighed, and analyzed for total solids, dissolved reactive P (DRP), bioavailable P (BAP), and total P (TPR).

Results and Discussion
Seasonal differences. The concentration in runoff (Figure 1) of DRP and BAP were higher in fall than in spring for all treatments. Similar seasonal trends were observed for DRP and BAP loads (Figure 2). Differences for TPR were not so consistent. The TPR concentration was somewhat higher in spring for most treatments and TPR loads were higher in the fall for most treatments. The P treatments and tillage were applied in spring, so the differences for DRP and BAP may be explained mainly by greater runoff in the fall (not shown). Less consistent, and sometimes opposite, seasonal trends for TPR can be explained by greater sediment loss in the spring, but factors such as different hydrological soil conditions and both greater residue cover and P leaching from residues in
the fall may have contributed.

**Runoff P concentrations (Figure 1).** The major result was that the three runoff fractions were consistently highest for CC harvested for total biomass and with N-based manure management. In the fall, the second highest concentrations were for CC harvested for grain and with N-based manure. These results were explained by differences in applied P, soil-test P levels, residue cover, and sediment loss (not shown). Other differences were small and often statistically not significant. The P concentrations tended to be lower for crops managed with fertilizer and for switchgrass, however, especially for TPR.

**Runoff P loads (Figure 2).** Differences for runoff P loads were less consistent across seasons and statistically less significant than for P concentrations, probably due to variable runoff across plots. In the fall however, loads for all runoff fractions were highest for CC harvested for total biomass with N-based manure management, as was the case for concentrations. Runoff P loads tended to be lowest for grain crops managed with fertilizers and for switchgrass.

**Soil-test P effects.** There were major soil P effects on runoff P across systems. As an example, Figure 3 shows relationships for DRP and BAP concentrations in runoff. There were clear differences between seasons in the relative impact of a soil P increase. This is demonstrated by steeper slopes of the linear trends in the fall. Runoff P loads showed similar trends but were more variable. Seasonal differences can be explained by tillage and P application in spring and a higher proportion of DRP and BAP of TPR in the fall. Tight relationships across all systems suggest that management system effects on runoff P were largely explained by the soil P levels associated with the different practices used.

**Conclusion**

The P loss with surface runoff was highest for continuous corn harvested for total biomass in combination with N-based swine manure management. This result was explained by less residue cover, higher P application rates, and higher soil-test P than for other systems. Differences among other systems were smaller, inconsistent, and often not statistically significant.
Figure 2. Runoff P loads by season. Bars with different letters differ statistically. See Fig. 1 caption for treatment and crop label names.

Figure 3. Relationships between soil P and dissolved and bioavailable runoff P concentrations.