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Impacts of Crop, Biomass Harvest Systems, and Nutrient Management on Yield and Subsurface Drainage Water Quality

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Abstract
Grain-crop biomass and perennial grass biomass are of particular interest for their use in bioenergy production systems. Nutrient needs, particularly nitrogen and phosphorus, change with varying cropping systems, harvest systems, and rates of fertilizer application. Furthermore, manure generated from livestock production can be a viable nutrient source for cropping systems, reducing the need for commercial fertilizers. The primary focus of this study was to investigate nutrient loss, primarily nitrate-nitrogen loss, in subsurface drainage water under a variety of cropping, nutrient management, and harvest scenarios. Overall crop yields and biomass production were also evaluated.

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Disciplines
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Introduction

Grain-crop biomass and perennial grass biomass are of particular interest for their use in bioenergy production systems. Nutrient needs, particularly nitrogen and phosphorus, change with varying cropping systems, harvest systems, and rates of fertilizer application. Furthermore, manure generated from livestock production can be a viable nutrient source for cropping systems, reducing the need for commercial fertilizers. The primary focus of this study was to investigate nutrient loss, primarily nitrate-nitrogen loss, in subsurface drainage water under a variety of cropping, nutrient management, and harvest scenarios. Overall crop yields and biomass production were also evaluated.

Materials and Methods

A variety of treatments were implemented on 27 plots with a subsurface drainage monitoring infrastructure. Treatment scenarios included three different cropping systems (continuous corn, corn/soybean rotation, and switchgrass), with varying nutrient management and harvest strategies, as summarized in Table 1. All fertilizer and manure was applied and incorporated in the spring of the year. Monitoring of drainage and collection of flow-weighted water samples was on-going on at least a weekly basis from April to November 2008 and then March to November 2009. Drainage water samples were analyzed for nitrate-nitrogen, total reactive phosphorus, and total phosphorus. Since there was very little treatment effects on phosphorus, just the nitrate-nitrogen data are presented.

Results and Discussion

Nitrate-nitrogen concentrations (Figure 1). Nitrate-nitrogen concentration data indicate higher concentrations in the subsurface drainage water from the continuous corn treatments receiving commercial fertilizer (4-32 mg/L) than those with manure treatment (1-10 mg/L). Switchgrass treatments resulted in low nitrate-nitrogen concentrations at or below 5 mg/L. Seasonal variations were observed; of particular note is an increase in nitrate-nitrogen concentration in early summer of both 2008 and 2009 for the commercial fertilizer treatments.

Crop results. Crop yields are presented in Table 2. Yields from 2008 were low due to delayed planting as a result of substantial rainfall at the project site in the spring of 2008. Yields increased dramatically in 2009, with the exception for soybeans. The continuous corn plots with commercial fertilizer applied consistently produced the highest yields. In addition to yield data, corn stalk nitrate samples were collected in October 2008 and 2009 (Table 3). In 2008, stalk nitrate levels were extremely low and well below the optimum range of 700–2000 mg/kg. In 2009, the commercial fertilizer treatments resulted in optimum stalk nitrate values, and all the manure treatments were below optimum. The trends in stalk nitrate resemble the trends observed in yields, with the highest yields occurring when the plant is able to store more nitrate in the stalk.

Conclusions

The highest crop yields were observed for the continuous corn treatments with commercial fertilizer applied. However, these treatments also resulted in the highest concentrations of nitrate-nitrogen in subsurface drainage water. Manure treatments resulted in relatively high yields and moderate concentrations of nitrate-nitrogen in subsurface drainage water, and switchgrass treatments yielded low nitrate-nitrogen concentrations. Seasonal variations in N were observed, particularly for the commercial fertilizer treatments.

Table 1. Listing of treatments and nitrogen application in 2009.

Treatment number	Cropping system	Nutrient management	Harvest	Nitrogen target (lb/ac)	Nitrogen applied (lb/ac)
1	Continuous corn	Fertilizer N and P	Grain	200	200
2	Continuous corn	Fertilizer N and P	Partial stover	200	200
3	Continuous corn	Fertilizer N and P	Total biomass	200	200
4	Continuous corn	Manure N and P	Grain	200	165
5	Continuous corn	Manure N and P	Total biomass	200	152
6	Corn/soybean	Manure N and P	Grain	150	117
7	Switchgrass	Fertilizer N and P	Total biomass	150	150
8	Switchgrass	None	Total biomass	--	--

Table 2. Crop yields for 2008 and 2009. Yield results corrected to 15% moisture for corn and 13% moisture for soybeans. Grain yields were not measured for treatments 3 and 5.

			Crop yield (bu/ac)	
Treatment number	Cropping system	Nutrient management	2008	2009
1	Continuous corn	Fertilizer N and P	111	181
2	Continuous corn	Fertilizer N and P	111	168
4	Continuous corn	Manure N and P	87	147
6	Corn/soybean - corn	Manure N and P	74	115
6	Corn/soybean - soybean	Manure N and P	59	49

Table 3. Corn stalk nitrate results from 2008 and 2009—20 mg/kg is the lower detection limit.

			Stalk nitrate (mg/kg)	
Treatment number	Cropping system	Nutrient management	2008	2009
1	Continuous corn	Fertilizer N and P	26	1907
2	Continuous corn	Fertilizer N and P	32	1483
3	Continuous corn	Fertilizer N and P	21	1683
4	Continuous corn	Manure N and P	24	287
5	Continuous corn	Manure N and P	<20	<20
6	Corn/soybean	Manure N and P	<20	<20

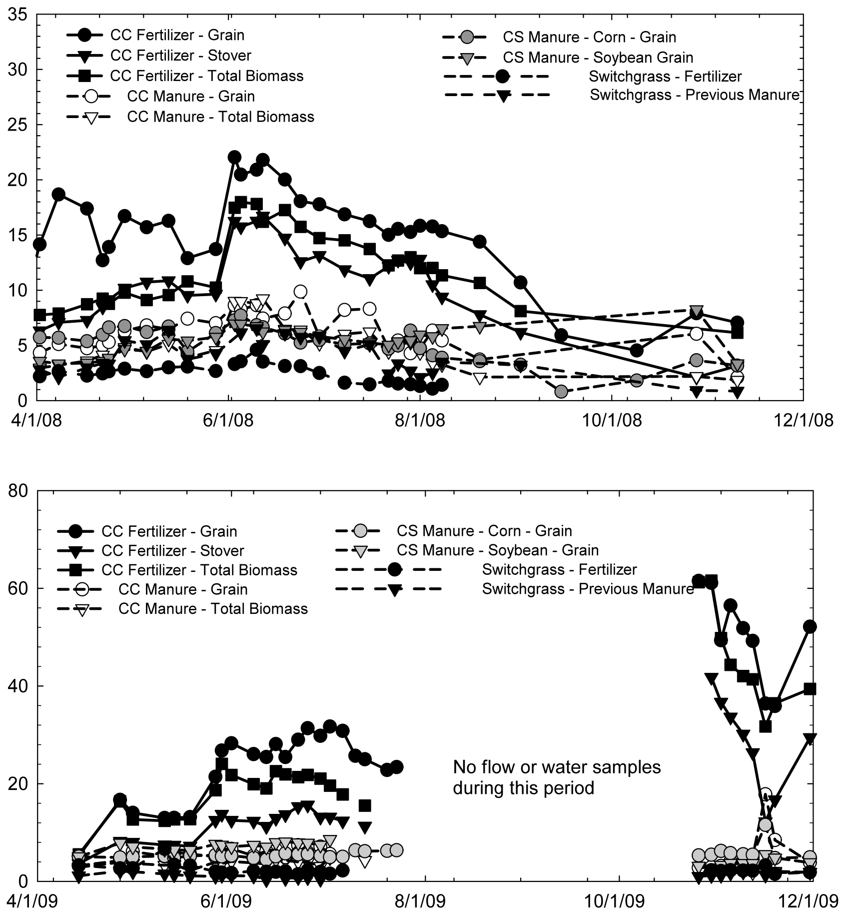

Figure 1. Flow-weighted nitrate-nitrogen concentrations in subsurface drainage water during 2008 and 2009 (note scale differences in 2008 and 2009).