Nitrate-N Loss with Drainage from Corn-Based and Prairie Bioenergy Cropping Systems

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Introduction

The Comparison of Biofuel Systems (COBS) project is a long-term, 20-acre field experiment designed to provide quantitative, side-by-side comparisons of corn- and prairie-based biofuel feedstock production systems with respect to biomass yields, liquid fuel potential, and multiple environmental impacts. The project was established in 2008 at ISU's South Reynoldson Farm in Boone County. Here, we report on nitrate-N loss with subsurface drainage.

Materials and Methods

The following five cropping system treatments contained within the COBS experiment are compared: 1) corn-soybean rotation with corn and soybean harvested for grain; 2) continuous corn harvested for grain and biomass; 3) continuous corn grown following a winter cover crop (rye) and harvested for grain and biomass; 4) multispecies reconstructed prairie grown without fertilizer and harvested for biomass; and 5) N-fertilized multispecies prairie harvested for biomass. Treatments were replicated four times and arranged in a spatially balanced complete block design. For treatment #1, both corn and soybean are present each year. The experimental site is dominated by two soil series: Nicollet clay loam (an Endoaquic Argiudoll) and Webster silty clay loam (a Typic Argiaquoll). Slopes at the site are largely ≤1 percent, with some small areas of 2–3 percent slope. Plots for the experiment are 90 ft x 200 ft, and all cropping systems are managed without tillage. Nitrogen application rates for the treatments are listed in Table 1.

Subsurface drainage lines were installed at a depth of 3.5 ft, parallel to the long dimension and through the center of each plot and on the borders between plots (45 ft). The subsurface drains at plot borders were installed to isolate the plots and to prevent lateral, subsurface drainage from adjacent plots. The center drainage line is monitored for drainage volume and flow-proportioned water samples are collected for water quality analysis.

To accommodate the sampling and monitoring systems, 12 metal culverts were buried vertically at the ends of the center drainage lines from pairs of individual plots. Drainage lines from the plots are directed to separate sumps in the culvert, and drainage water is pumped through plastic plumbing fitted with a plated sprayer nozzle and a water meter. Back pressure created by the meter forces a constant fraction (~0.25%) of all drainage to be diverted to a 10-L sampling bottle. The in-line flow meter is read when water samples are taken approximately twice weekly when there is flow. This unique configuration provides the infrastructure for continuously monitored flow-volume measurements and flow-integrated sampling of subsurface drainage from each plot.

Results and Discussion

From 2010 through 2016, tile drains in each of the 24 plots were sampled to determine soil water fluxes and to assess the export of nitrate-N in drainage water. Over this seven-year time period the greatest nitrate-N loss was from the corn-soybean system, which

combined across the corn and soybean phase had a cumulative nitrate-N loss of about 140 lb-N/acre (Figure 1). Despite higher nitrogen application in the continuous corn with cover crop treatment, the nitrate-N loss was less than under the continuous corn with no cover crop. In contrast to the corn-based systems, the prairie, whether fertilized or unfertilized, had cumulative nitrate-N loss of less than 10 lb-N/acre. This research illustrates the dramatic nitrate-N reductions that could be achieved with prairie bioenergy-based cropping systems.

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Table 1. Nitrogen application rates from 2010-2016.

	Nitrogen application rate (lb/ac)							
Treatment	2010	2011	2012	2013	2014	2015	2016	Avg.
Corn in corn-soybean rotation	94	113	198	221	180	205	125	162
Continuous corn	110	128	179	221	160	190	145	162
Continuous corn with cover crop	151	198	198	221	145	205	115	176
Fertilized prairie	75	75	75	75	75	75	88	77

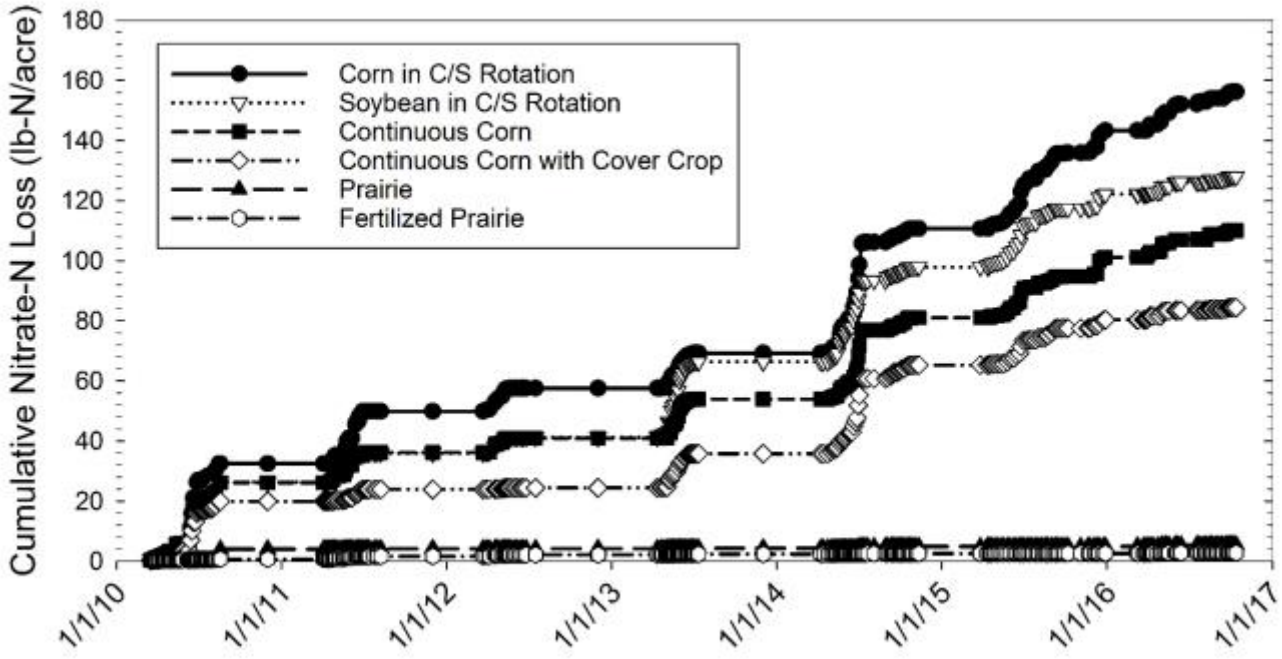

Figure 1. Nitrate-N loss from 2010-2016.