2016 Annual Report for NREC Project-02539

Evaluating Nutrient Loss Reduction Strategies: Longer rotation with cover crops and bioreactor

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Objectives

The overall goal of this study is to test the effectiveness of a longer rotation with cover crops in combination with a bioreactor to decrease tile nitrate loss and directly examine this potential nutrient loss reduction scenario on a field-scale production system.

Specific objectives are to:

1. Determine the effect of a C-S-W rotation with cover crops on crop yields, nutrient cycling, field hydrology, and nitrate leaching on field scale plots.
2. Examine the role of cover crops in nitrogen availability to the subsequent corn crop.
3. Determine field N balance and relate to tile nitrate load.

This report summarizes results from the second year of the project.

Treatments

- Three pattern-drained, field-scale plots (55-75 A) in either: corn, soybean or winter wheat, accommodating each phase of the rotation every year.
- Cereal rye after corn, winter wheat after soybean, and radish, turnip and red clover after winter wheat.
- Strip-till corn, no-till soybean and no-till wheat.

Methods

- Measure tile flow and nutrient concentration in and out of bioreactors.
- Measure cover crop biomass and biomass N.
- Determine crop grain yield and nutrient accumulation.
- Conduct corn N rate trial and sample inorganic N status at R1 and R6

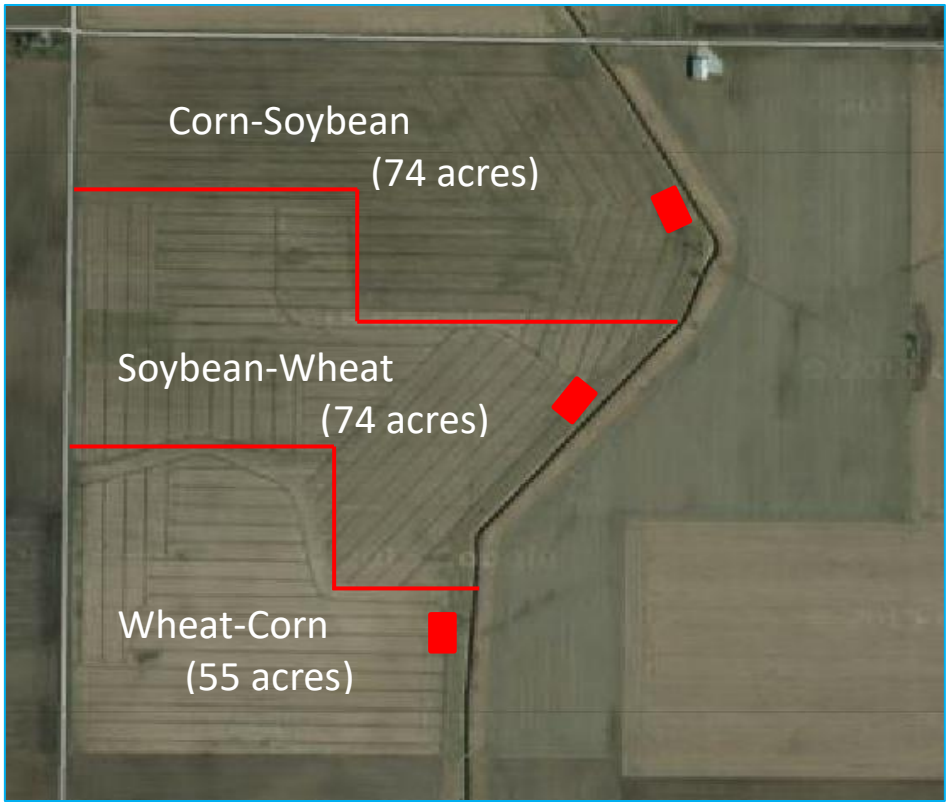

Figure 1. Field boundaries, field size, and crop location in 2015-2016.

Tile Nitrate Results from 2016

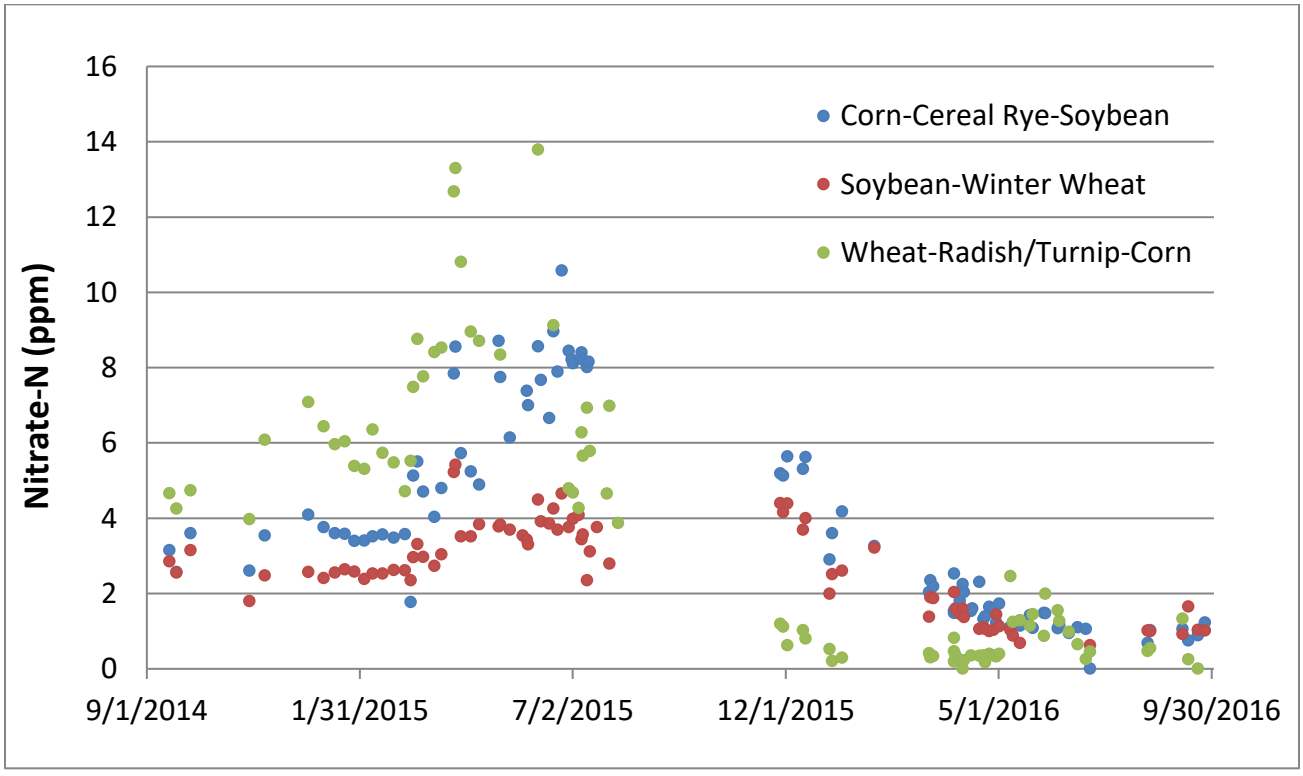

Figure 2. Tile nitrate concentrations from the three tile systems draining either: corn, soybean or winter wheat production from 9/1/14 through 9/30/16.

The presence of cover crops in the three year rotation greatly tightened the N cycle as indicated by the low tile nitrate concentrations coming from each field in the second year of this study (Figure 2). Cover crop biomass and biomass N are shown in Tables 1A, 1B, and 1C. In only one growing season, tile nitrate loss greatly decreased. Final annual tile flow values will be verified soon, but preliminary load calculations suggest tile N loads decreased by 50% with the addition of cover crops in this rotation. This data provides proof of concept that cover crops can act as a N catch crop to keep nitrate from leaching through the rooting zone and into tile drainage systems.

Cover Crop Biomass from 2016

Table 1A. Total biomass of cover crops and volunteer wheat determined on November 15, 2015.

Cover Crop (Fall)	Biomass	Biomass N
	tons/A	lbs/A
Radish	1.67	55
Turnip	0.73	20
Red Clover	0.26	15
Volunteer wheat	0.21	10
Total	2.87	100

Table 1B. Total biomass of red clover and volunteer wheat determined on April 14, 2016.

Cover Crop (Spring)	Biomass	Biomass N
	tons/A	lbs/A
Red Clover	0.49	38
Volunteer Wheat	0.40	20
Total (Spring)	0.89	58

Table 1C. Total biomass of cereal rye after corn determined on April 14, 2016.

Cover Crop (Spring)	Biomass	Biomass N
	tons/A	lbs/A
Cereal Rye	0.61	21

Establishing a "Control" Treatment in 2016

Following patterned tile installation on the east side of the ditch in 2015, we installed Agridrain structures to monitor tile nitrate concentrations and loads draining a conventional corn-soybean rotation (Figure 3). These two fields on the east side will serve as our "control" treatment for comparisons of crop yields and tile nitrate loss with the 3 yr rotation. Tile monitoring equipment was installed and nutrient samples were collected and analyzed throughout the year.

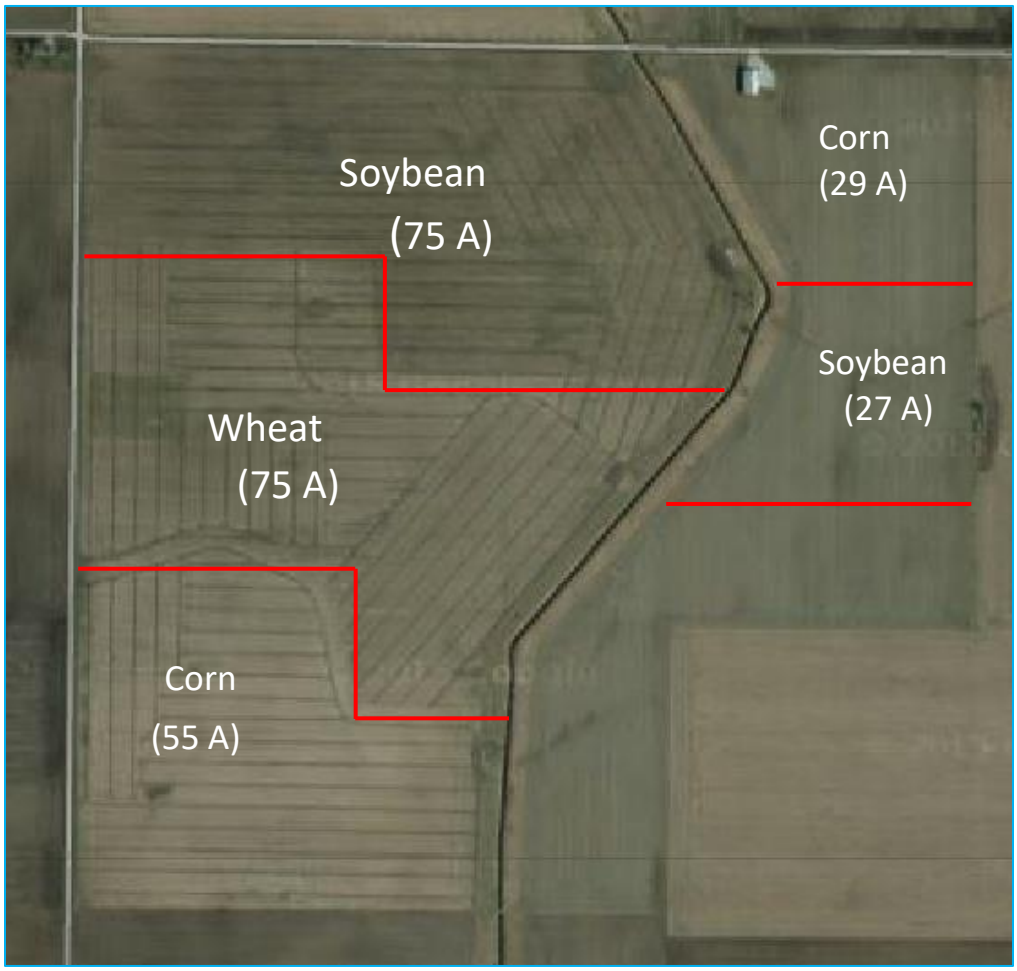

Figure 3. Field boundaries, field size, and crop location in 2016

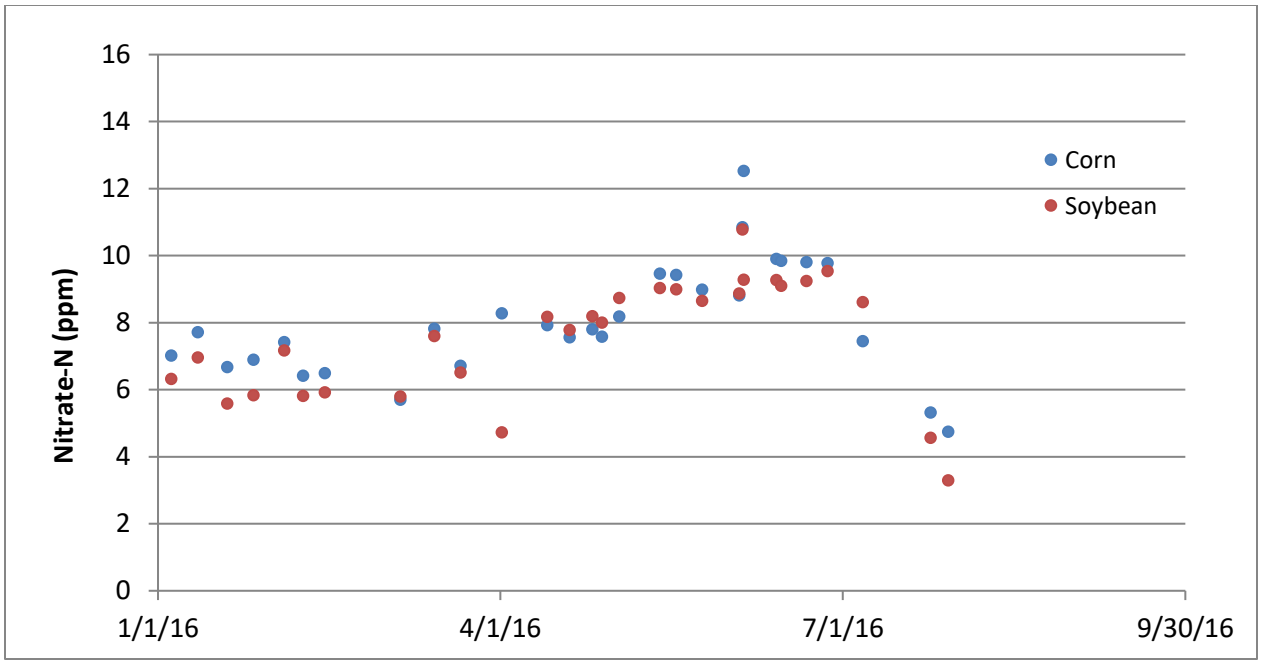

Figure 4. Tile nitrate concentrations from the "control" treatment (corn or soybean production) from 1/4/16 through 9/30/16.

Tile nitrate concentrations ranged from a low of 3.5 ppm for soybean production in late July to a high of 12.5 ppm for corn production in early June (Figure 4). These tile nitrate values are much greater than tiles draining the C-S-W production system for the same time period (Figure 4 vs. Figure 2).

Crop yields in 2016

Table 2. Crop yields in 2016 for both the 3-yr rotation and the 2-yr rotation. A 3 acre test plot of double cropped soybean was established after wheat.

Crop	C-S-W	C-S
	bu/A	bu/A
Corn	214	236
Soybean	75	86
Wheat	101	-
Double Crop Soy (3 acre test plot)	54	-

Crop yields were excellent in 2016; however, there were differences in corn and soybean yields between the two production systems (Table 2). For soybean, the difference was due to maturity group and planting date. A 2.9 maturity group was used in the C-S-W system vs. a 4.1 maturity group in the control treatment. Also, soil with cereal rye dried slower and soybean planting occurred 2 weeks later than in the control treatment without a cover crop.

For corn, yield differences between the two systems were due to fertilization rate and potential interference of the cover crop. Fertilizer N rate was 170 lbs/A to corn in the control treatment; however, we gave the cover crop a 30 lb/A N credit, thus applying only 140 lbs/A to corn in C-S-W.

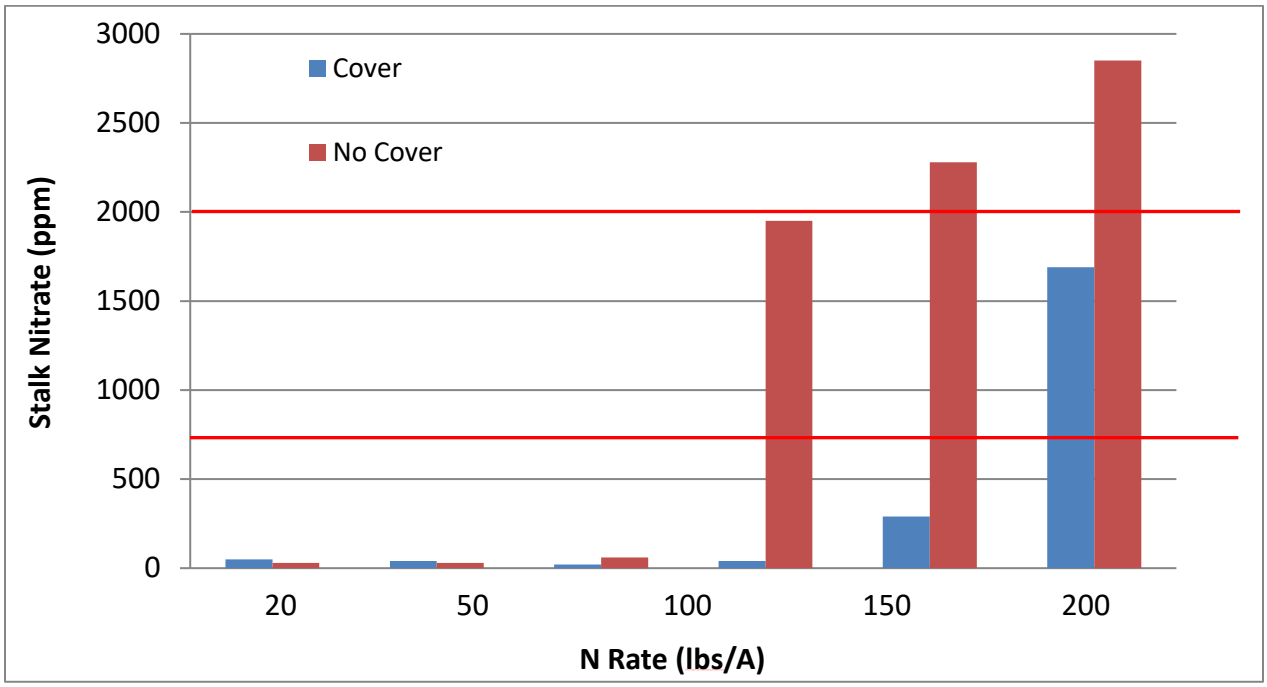

Figure 5. Corn stalk nitrate evaluation comparing N rates studies in corn after wheat with and without a cover crop.

Stalk nitrate concentrations from N rate trials located in both corn fields revealed another cause for the difference in corn yields between the two systems, less available N presumably from an increase in N immobilization following the large cover crop biomass after wheat (Figure 5). Note: both corn fields were preceded by winter wheat in 2015 which allowed for the comparison of corn following winter wheat with and without a cover crop.

Corn yields and the economic optimum N rate (EONR) from the N rate trials are shown in Figure 6. The cover crop increased the EONR by about 60 lbs of N/A and decreased the yield at the EONR by about 10 bushels per acre. At current prices that would mean a “return to N” of $59 per acre less (60 x $0.37 + 10 x $3.70 = $59) for corn after wheat with the cover crop vs. corn after wheat without the cover crop. This is a surprising finding but it is consistent with the stalk nitrate data. We may have had too much of a good thing with the huge amount of cover crop biomass (that had rather poor quality) (i.e. wide C/N ratio, especially in the roots of the radish and turnip).

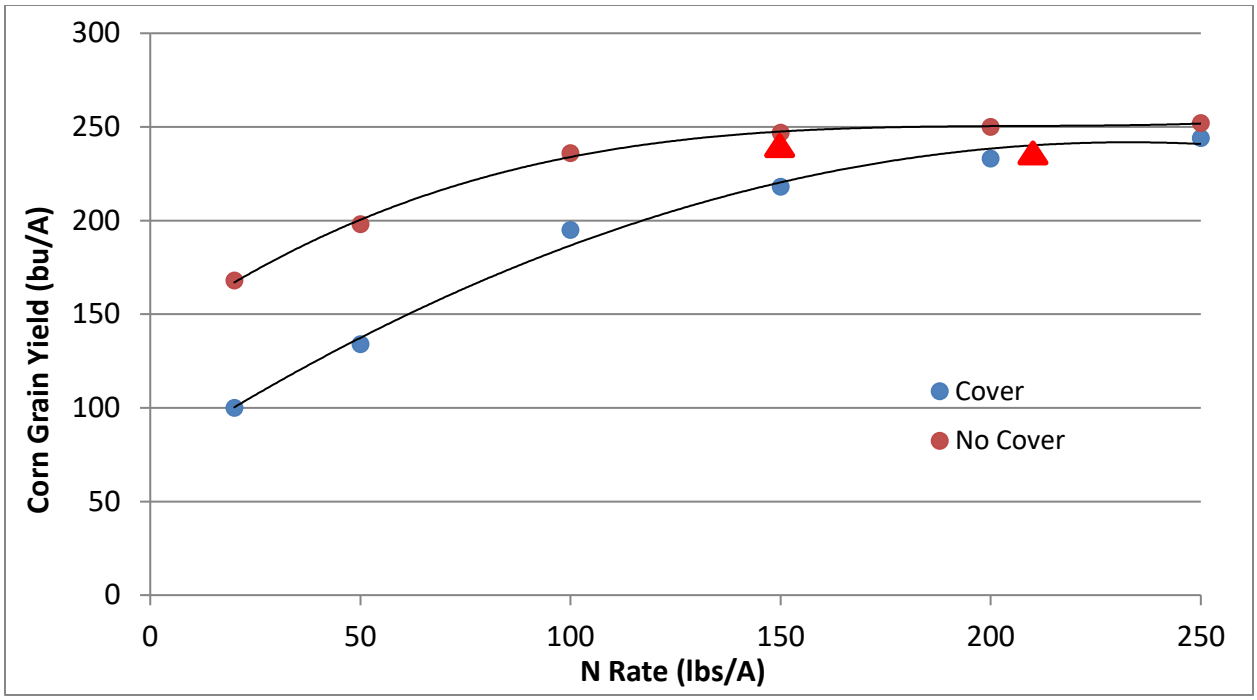

Figure 6. Corn grain yield and economic optimum N rate (indicated by red triangle) for N rates studies in corn after wheat with and without a cover crop.

The three woodchip bioreactors receiving drainage from the C-S-W system were evaluated this year. The bioreactor at the end of the 2015 corn field treated the tile water with the greatest nitrate concentration and bioreactor performance is shown in Figure 7.

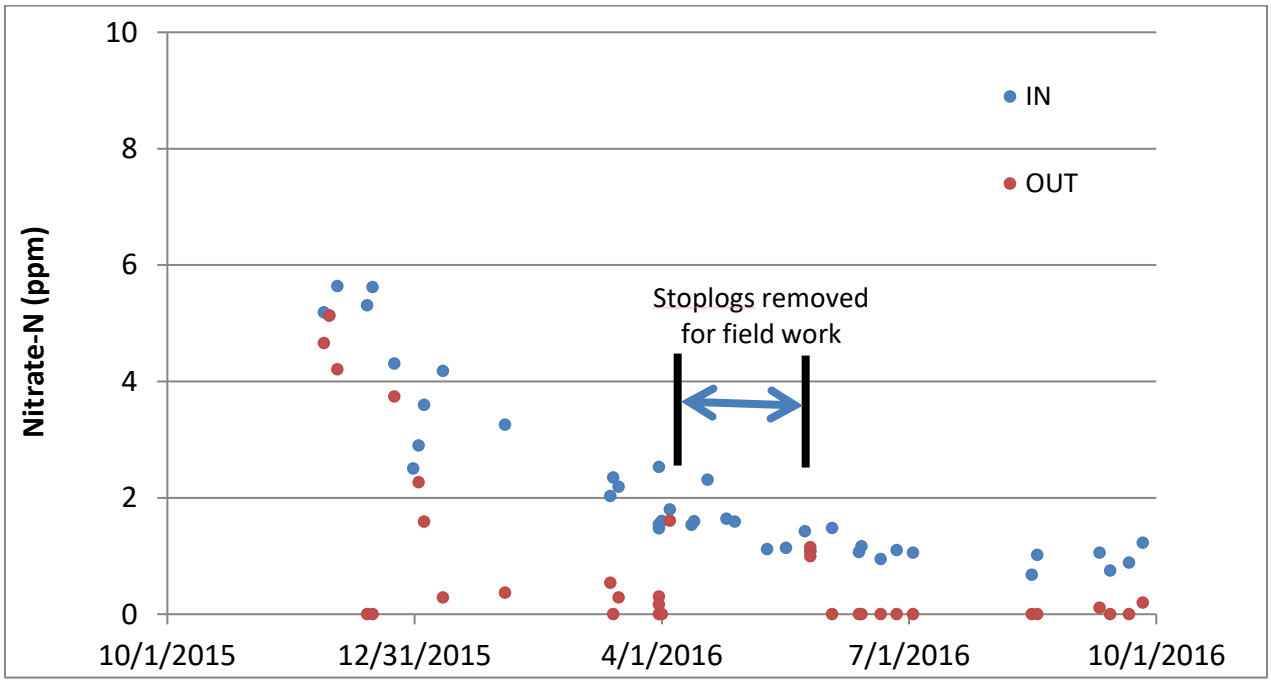

Figure 7. Nitrate in and out of the bioreactor receiving tile water from the corn-cereal rye-soybean phase of the C-S-W production system.

In general, bioreactors performed well and most nitrate entering the woodchips was removed/denitrified. As spring and summer temperatures increased tile water temperatures, tile nitrate was often completely removed (May through September) via the bioreactor. One of the limitations of bioreactor performance is that cold tile water temperatures limit microbial activity and nitrate removal. Also, at extremely high tile flow, the majority of the tile water can bypass the woodchips and go untreated, which occurred on 5 occasions following rain events.

With the addition of the control treatment as well as two treatments for our new NREC proposal (Cereal rye ahead of corn), we are now monitoring the performance of 6 bioreactors on this farm. We are cooperating with NRCS and reporting stoplog settings to the State Ag Engineer.

Highlights:

- A longer rotation (C-S-W) with cover crops greatly reduced tile nitrate concentrations.
- Combining two IL NLRS techniques (cover crops and bioreactors) in one field nearly eliminated nitrate loss from 200 acres in one growing season.
- We added a control treatment (conventional C-S system) to compare and contrast crop yields, N cycling, and tile nitrate loss in the C-S-W system.
- The N rate studies were very useful in explaining differences in corn yields between the two systems. Dan Schaefer does a great job setting up and harvesting the N rate trials.
- We added three bioreactors for a total of 6 monitored bioreactors on this farm.

Challenges:

- Radish/turnip/red clover cover crop appeared to immobilize N, decreasing crop N availability and increasing the EONR of corn by 60 lbs/A.
- Soybean varieties used in the C-S-W production system will likely need to be of a shorter relative maturity compared with the conventional C-S production system and this may decerse soybean yield potential.
- We continue to refine our tile flow estimates during periods of ditch flooding, however, we have instrumentation deployed now that measures tile velocity during times when the ditch water rises and submerges tile outlets.

We thank NREC for their continued support of this research. We believe this study demonstrates the potential to greatly decrease tile nitrate loss from production agriculture and that long lag times do not exist for improving water quality (at least for nitrate). The combination of a longer rotation with cover crops and a bioreactor can nearly eliminate nitrate loss via tile drainage, hower, we must carefully document any agronomic and economic disadvantages these systems impart to the producer before making recommendations at this time.