Evaluating nutrient loss reduction strategies: Longer rotation with cover crops and bioreactors

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2015 Annual Report to NREC

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

Objectives

- Provide on-farm evaluation using scenarios from the IL Nutrient Loss Reduction Strategy.
- Determine the effect of a C-S-W rotation with cover crops on crop yields, nutrient cycling, and field hydrology.
- Examine the role of cover crops in nitrogen availability and determine the N credit to the subsequent corn crop.
- Conduct a corn N rate trial to determine optimum N rate.
- Determine field N balance and relate to tile nitrate load.

Methods

- C-S-W with each phase of the rotation every year.
- Cereal rye after corn, winter wheat after soybean, and radish, turnip and red clover after wheat.
- Strip-till corn, no-till soybean and no-till wheat.
- Split application of N to wheat and corn.
- N rate trial (0, 50, 100, 150, 200, 250 lbs of N/A) with % N in grain, kernel weight and number, and stalk nitrate analysis.
- Soil sampling for inorganic N.
- Measure tile flow and nutrient concentration in and out of bioreactors.
- Cover crop biomass and biomass N.

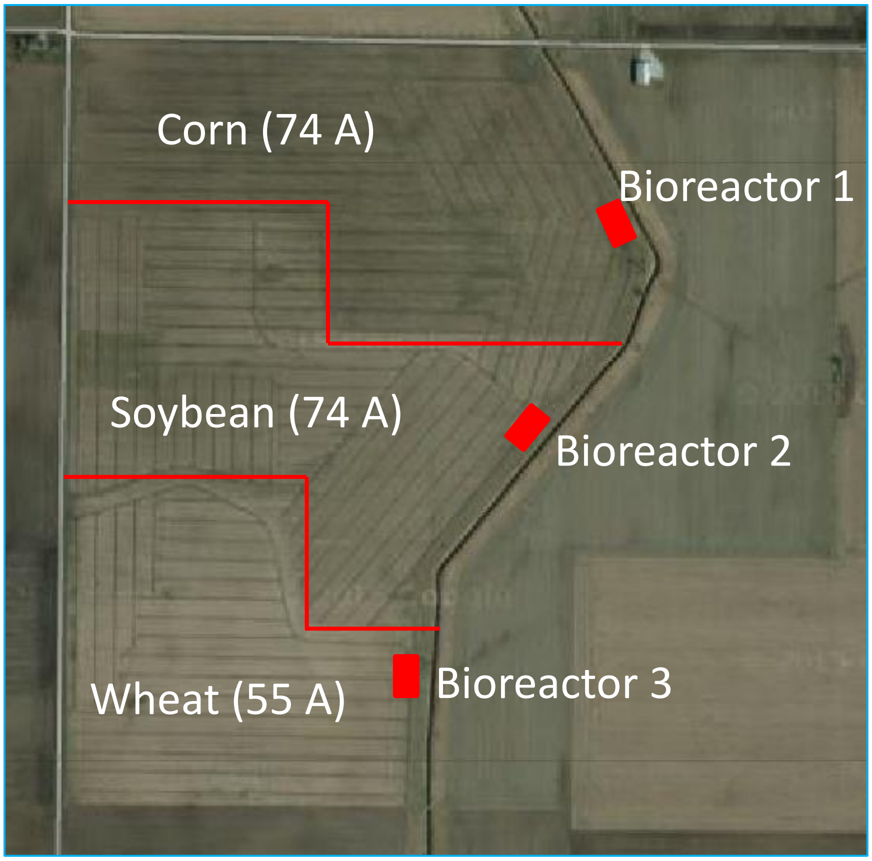

Figure 1. Tile map, field boundaries, and crop location in 2015.

Corn system: Corn (DeKalb 64-87) was planted on April 29, 2015 at 37,000 plants/A with 20 lbs of N/A of starter (combination 2x2 and pop-up). On May 29, corn was side-dresses with 28% at 160 lbs of N/A. At this time the N rate trial was established within the corn field using 500 ft long plots with 3 replicates. Dan Schaefer helped with design and setup. Soil samples were collected in N rate trial on July 15 and September 8. At physiological maturity, 8 plant samples (every 7th plant) were collected from 17.5 ft of the middle two yield rows in the N rate study. Ears and a lower stalk sections were collected and analyzed. Corn was harvested on September 30.

Soybean System: Soybean (Asgrow 2935) was planted at 135,000 plants/A on May 4, 2015. Soybean was harvested on September 25.

Wheat system: On October 25, 2014, 12-40-0 was applied to wheat acres (24 lbs of N/A). Winter wheat (Beck's 125) was planted on October 27, 2014. On April 1, 2015, 100 lbs of N/A (Super U with stabilizers) was top-dressed on wheat. Wheat was harvested on July 20, 2015.

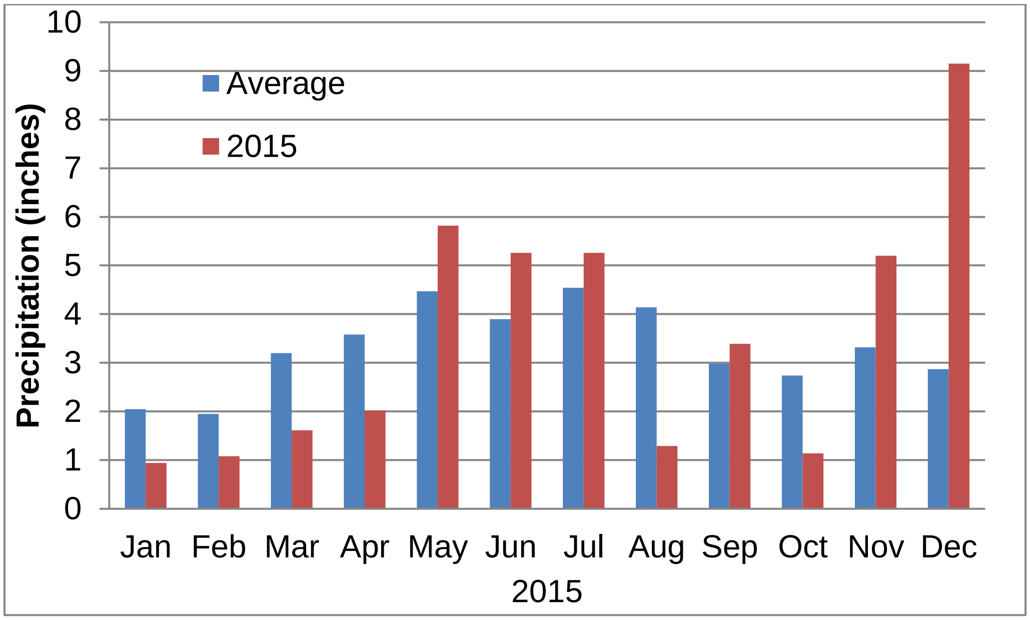

Figure 2. Precipitation measured on site during 2015 compared to local 30 year average.

Precipitation was timely and sufficient on site in 2015 for excellent crop growth and overall productivity. Unlike many areas of Illinois, rainfall was not excessive and ponding in the field did not occur. Corn yield was 253 bu/A, soybean was 83 bu/A and winter wheat was 76 bu/A in 2015. Wheat yield may have been reduced by a delay in harvest due to wet weather.

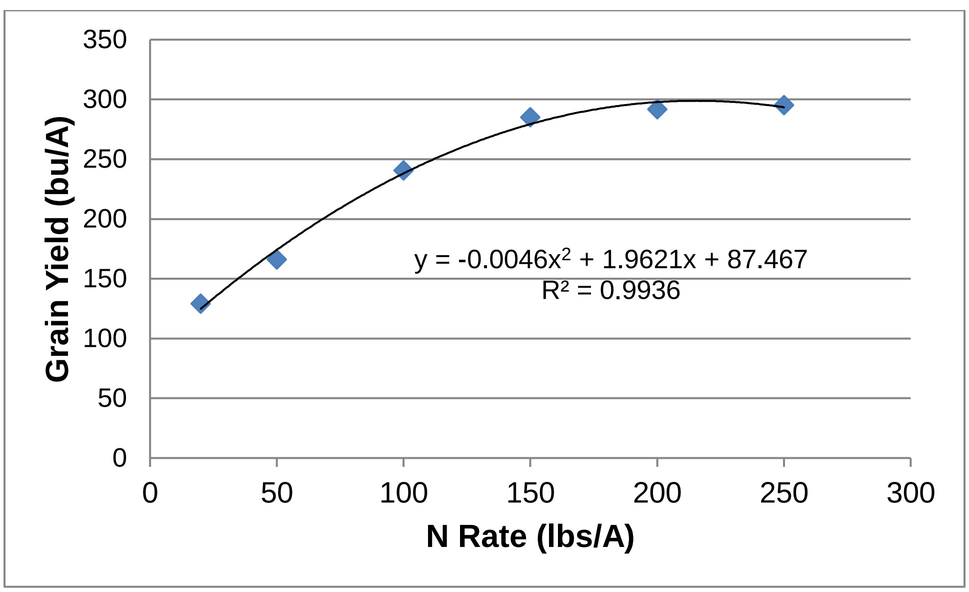

Figure 3A. Corn yields at various N rates based on combine harvest of the middle six rows.

The corn N rate trial showed a maximum yield of nearly 300 bu/A at a rate of 200 lbs of N/A.

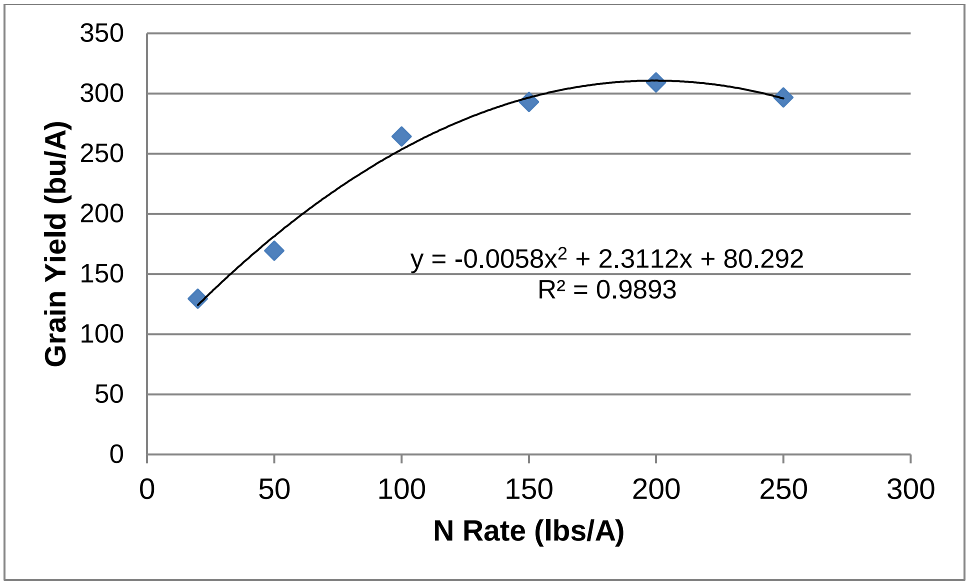

Figure 3B. Corn yields at various N rates based on a random sampling of 8 plants within the two middle yield rows.

The yield curves for both sampling techniques are similar and support the use of the 8 plant samples for further analyses. We determined kernel weight (300 kernel counts) to estimate kernel number per ear. We found that kernel number was maximized (approximately 550 kernels/ear) at the 100 lb/A N rate whereas kernel weight continued to increase (>300 mg/kernel) until the 200 lbs/A N rate. It appears that the reason for the large corn yield in this field was due to excellent conditions during grain fill.

The optimum N rate occurred between the 150 and 200 lb/A N rates. Stalk nitrate values showed the same trend with 510 ppm of nitrate at the 150 lb/A rate and 4,430 ppm of nitrate at the 200 lb/A rate. These data support the producer's overall field N rate of 180 lb of N/A for corn. In addition, soil samples showed that the 250 lbs/A N rate had substantial amounts of N left over at harvest.

320 mg/kernel x 555 kernels/ear x 37,000 plants/A = 300 bu/A

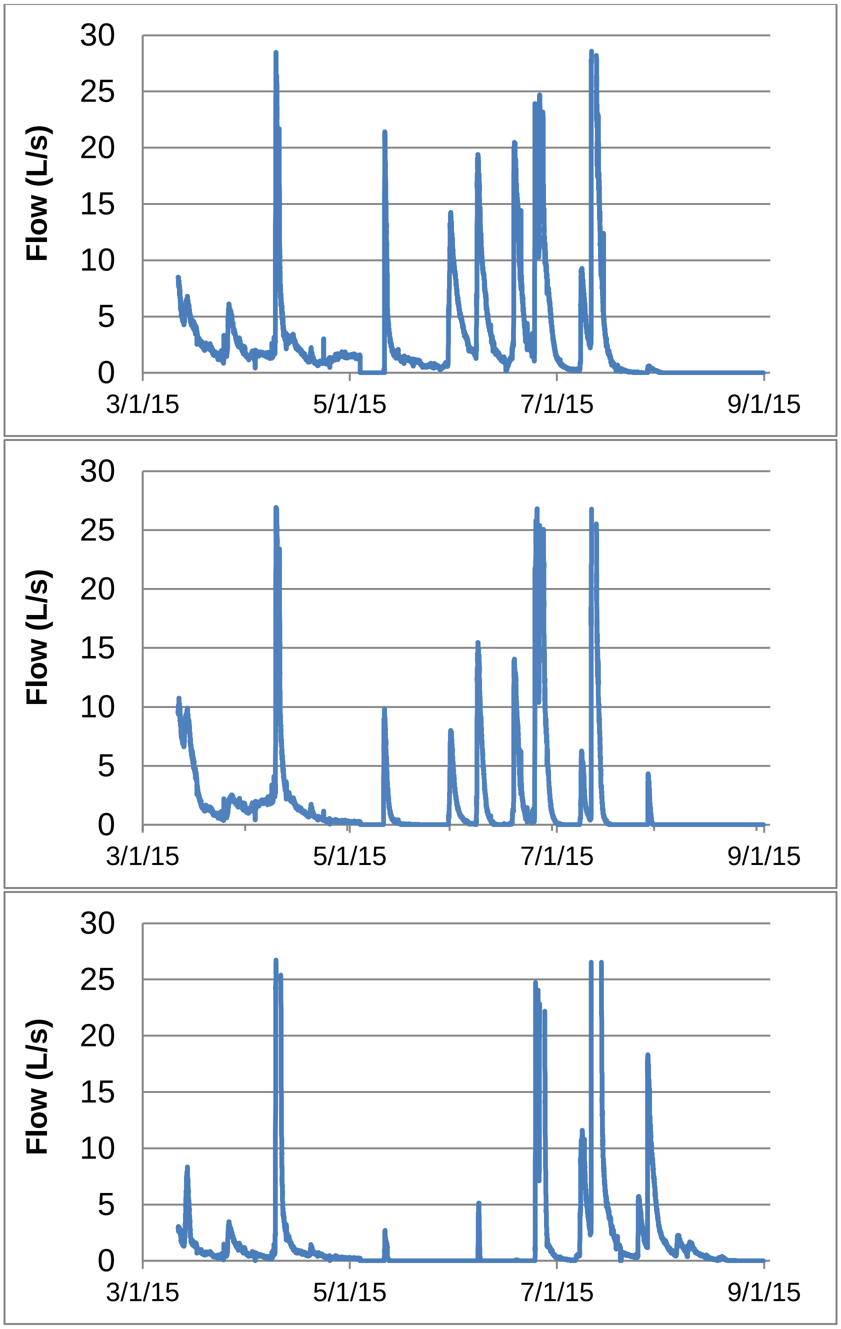

Figure 4. Flow from each tile system during 2015.

Tile flow monitoring began March 11, 2015. There was an obvious lack of tile flow from the wheat field during May and June compared with flow from either the corn or soybean field. This is a period of rapid growth for wheat and rainfall events of more than an inch on May 11, May 31, and June 8 produced very little flow from that field compared to flow from the corn and soybean fields. From March 11 through June 30, tile flow from the wheat field was only 1.2 inches whereas flow from the corn and soybean fields at that time was 2.6 and 4.0 inches. This difference in tile flow caused tile nitrate loads to be the least under wheat production. However, with continued rainfall throughout July, tile flow resumed from the wheat field following wheat senescence. Ultimately, the wheat field had nearly as much total tile flow and N loss as the corn field. The soybean field had the most tile flow, but had the lowest tile nitrate concentrations. Overall, nitrate loss was similar among the 3 fields. This experimental design with large plots will allow us to more accurately represent field hydrology and tile nutrient loads than can be attained on small plot studies.

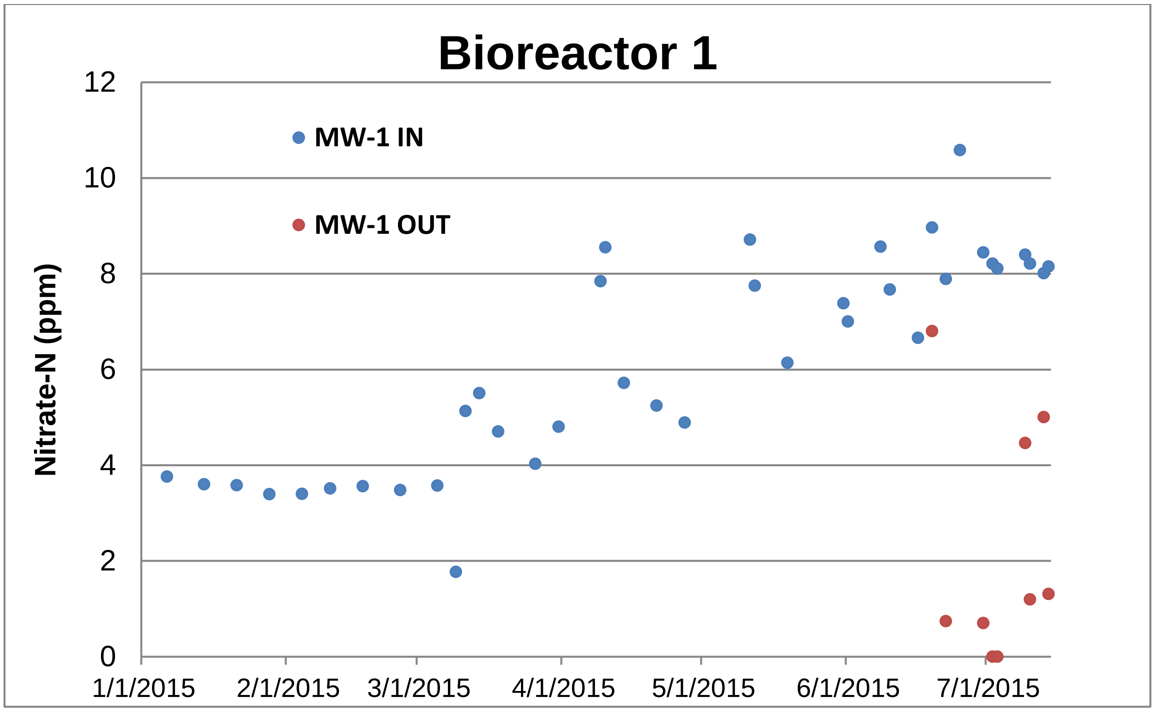

Figure 5. Nitrate concentrations in and out of Bioreactor 1 (corn production in 2015).

Bioreactors were inspected by NRCS and stop logs were positioned to begin diverting water through the wood chips on June 19, 2015. All three bioreactors removed more than 50% of the tile nitrate during July. This was a favorable period for bioreactor performance as tile water temperature reached a maximum at this time. In addition, from past work we have detected a new wood chip effect (high dissolved organic carbon) that can inflate bioreactor performance during the first year of operation. This study will allow us to re-investigate this effect and further evaluate the trade-off between water retention within the wood chips and bypass flow of tile water (tile flow that bypasses the wood chips during high flow events and goes untreated).

Cover crops were planted following crop harvest. Following winter wheat harvest, a mixture of radish, turnip, and red clover were drilled on August 15, 2015. Although sprayed with Gramoxone, volunteer wheat was substantial and added to the overall biomass production. Cereal rye was drilled following corn harvest on October 3, 2015. Following soybean harvest, winter wheat was planted on October 4, 2015.

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

Cover Crop	Biomass
	tons/A
Radish	1.67
Turnip	0.73
Red Clover	0.26
Volunteer wheat	0.21
Total	2.87

The total biomass production (cover crops plus volunteer wheat) was nearly 3 tons/A with radish making up the majority (60%) of the total biomass. This large amount of biomass demonstrates the importance of an extra month of cover crop growth in central Illinois. We measured above and below ground portions for both radish and turnip. It is interesting to note that the shoot to root ratio of the radish and turnip was nearly 1:1. The radish and turnip have winter killed and the red clover is expected to regrow in the spring. It is possible that the red clover will absorb some of the N that releases from the radish and turnip.

Red clover and cereal rye biomass will be determined prior to glyphosate application in the spring. Dried cover crop biomass samples will undergo a complete nutrient analysis. With these results, we will determine an N credit to corn based on the assumption that 50% of the total biomass N of the cover crop will become available to the subsequent corn crop. We will collect soil samples throughout the spring for inorganic N analyses to investigate cover crop N release. If it appears that N is released from the radish and turnip too early, we may lower our N credit value. It is possible that tile nitrate concentration may increase during late winter and early spring from this field, suggesting that early N release from the cover crop is being lost.

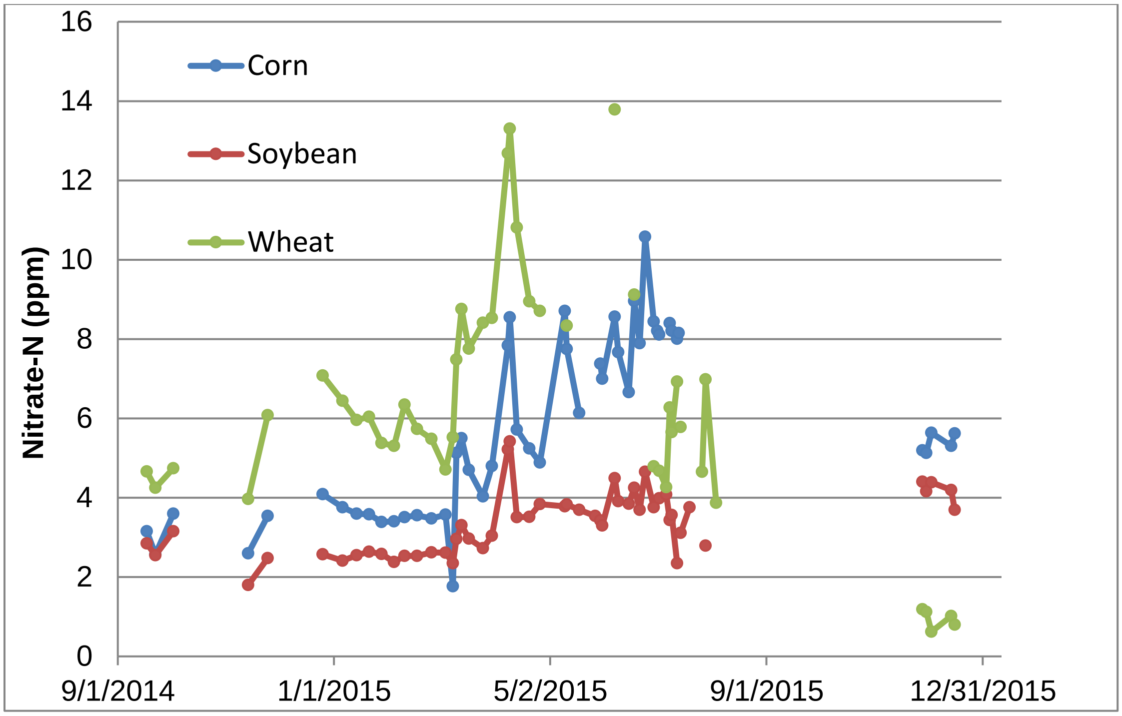

Figure 6. Tile nitrate concentrations from the three tile systems draining either corn, soybean or winter wheat production in 2015.

Tile nitrate concentrations varied among the three fields, although initially they were at a similar low level. (Note: all three fields were planted to wheat 2014).

Tile nitrate concentrations from wheat production which had received 24 lbs of N/A from fertilizer P application were greatest (peak of 13.9 ppm) in the winter and early spring of 2015. All three tile systems showed a spike in nitrate concentration on March 14 and April 10, which may indicate a flush of mineralized soil N to the tile lines. We presume that a cover crop occupying the soil at this time would prevent a loss of N from soil mineralization.

For corn production, tile nitrate concentrations steadily increased throughout the drainage season and reached the greatest value (10.6 ppm) on June 25. The first spike in tile nitrate concentration occurred after starter N application on May 11(a flow event that produced no increase in tile nitrate from soybean or wheat production). The flow event on June 25 likely flushed some of the side-dress N into the tiles.

Tile nitrate concentrations from soybean production remained below 5 ppm throughout the drainage season and reached a high of 5.6 ppm on April 10. Soybean received no fertilizer N and the tile system that drains soybean can be used as a “control” treatment in comparison to the other two tiles in any given year as the crops rotate through the cycle.

Overall, timing and amount of fertilizer N appeared to influence the tile nitrate concentration and pattern for a given field. In addition we saw clear evidence of soil mineralization inputs into the tile systems.

When tile flow resumed at the end of November, 2015, tile nitrate concentrations were lower for both wheat and corn production systems, however, no change for the soybean production system. Tile nitrate concentrations were below 1ppm from wheat production in December. Soil sampling to a depth of 2 feet on December 11 in wheat production (with radish + turnip + red clover) showed that soil contained only 1 or 2 ppm of nitrate suggesting that the abundant cover crop growth decreased soil inorganic N and reduced nitrate leaching. Tile nitrate from corn production followed by cereal rye was lower than before tiles stopped flowing (<6 ppm). Soybean followed by winter wheat appeared to have no influence on tile nitrate concentration; however, approximately 25 lbs of N/A was applied with fertilizer P in the fall.

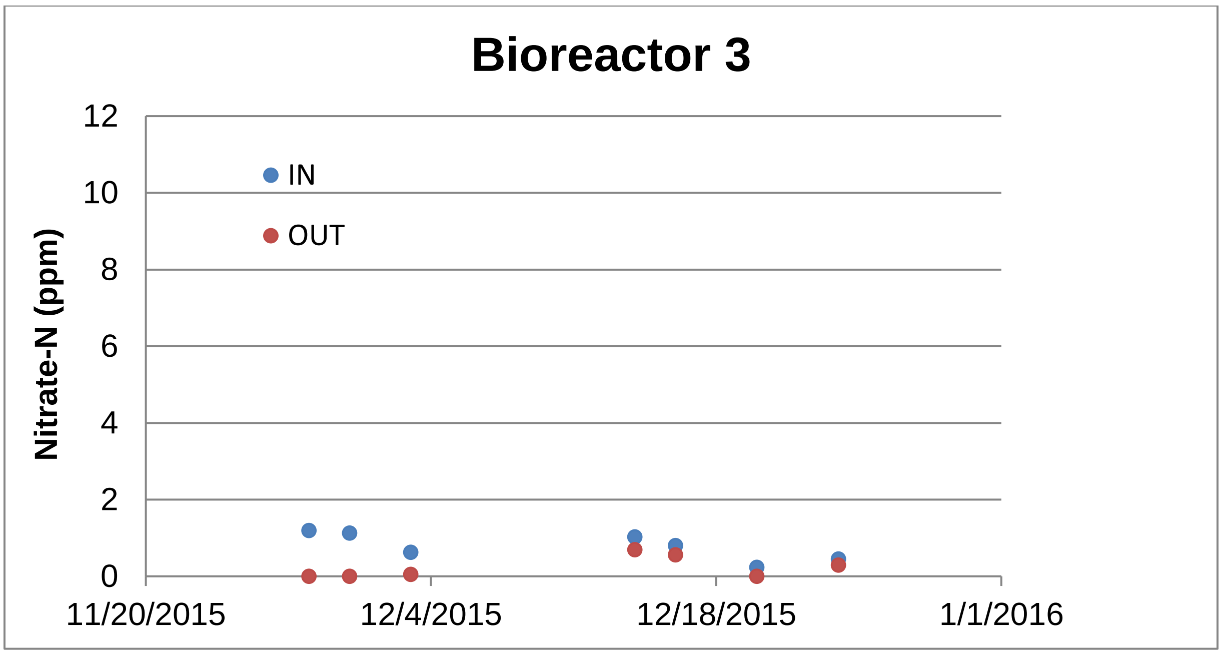

Figure 7. Nitrate concentrations in and out of Bioreactor 3 (following winter wheat/cover crops).

This figure shows the low tile nitrate concentrations that entered into the bioreactor following winter wheat/cover crop production. The bioreactor completely removed nitrate from the tile at the end of November and early December, but removal slowed as tile water temperatures declined (tile temperature measured but not shown here). **Overall, we found that within one growing season we could greatly decrease tile nitrate concentrations with winter wheat and cover crops. This experiment demonstrates proof of concept that cover crops can act as a catch crop and decrease tile nitrate.**