2017 Final Report Summary Sheet

Grantee Information

Project Title: Evaluating nutrient loss reduction strategies: longer rotation with cover crops and bioreactor Cereal Ry

Institution: University of Illinois

Primary Investigator: Gentry

NREC Project # 2015-5-360350-374 2017-3-3

Is your project on target from an IMPLEMENTATION standpoint? ☒ Yes ☐ No

If you answered "no" please explain:

Is your project on target from a BUDGET standpoint? ☒ Yes ☐ No

If you answered "no" please explain:

Based on what you know today, will you meet the objectives of your project on-time and on-budget? ☒ Yes ☐ No

If you answered "no" please explain:

Have you encountered any issues related to this project? ☒ Yes ☐ No

If you answered "yes" please explain:

On flat fields bioreactors can reduce tile flow by as much as 50%. Thus, we have a pool of nitrate that is unquantified and may reduce overall bioreactor performance. We plan to install shallow wells to investigate fate of retained water.

Have you reached any conclusions related to this project that you would like to highlight? ☒ Yes ☐ No

If you answered "yes" please explain:

- 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.
- There was no yield drag from cover crops in 2017.
- Wheat/double crop soybean was the most profitable production system.

Have you completed any outreach activities related this project? Or do you have any activities planned? ☒ Yes ☐ No

If you answered "yes" please explain and provide details for any upcoming outreach:

During 2017, outreach activities included 13 invited presentations by Lowell Gentry at various events such as: the Crop Management Conferences held throughout the state; annual meetings by IFCA and LICA, and local meetings (i.e. Ford/Iroquois County Extension and the Champaign County Farm Bureau. Collectively, we estimate that >1500 people attended these meetings and conferences.

2017 Annual Report for NREC Project

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

Lowell Gentry and Mark David
University of Illinois at Urbana-Champaign

Synopsis:

This project will provide an on-farm evaluation of best management practices, both in-field and edge of field, to demonstrate how low we can go in regard to tile nutrient losses. The University of Illinois Science Assessment which served to guide the Nutrient Loss Reduction Strategy evaluated combinations of nutrient remediation techniques to create BMP scenarios that when adopted regionally would make a significant reduction in the N and P export from agricultural runoff (overland and tile flow). Two remediation techniques that were often included in the various scenarios were 1) growing winter cover crops and 2) constructing woodchip bioreactors on drainage tiles. This proactive research is demonstrating the potential of maintaining high-yielding systems with minimal nutrient losses and is directly testing scenarios used in the University of Illinois Science Assessment. Considering the challenge the agricultural sector faces in regard to reducing nutrient losses to surface waters, this experiment will demonstrate the potential to reduce tile nutrient loss (especially nitrate) on a field scale. In direct response to the Illinois Nutrient Loss Reduction Strategy, this type of research will show that voluntary actions can work to improve water quality and that regulation is not warranted at this time.

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:

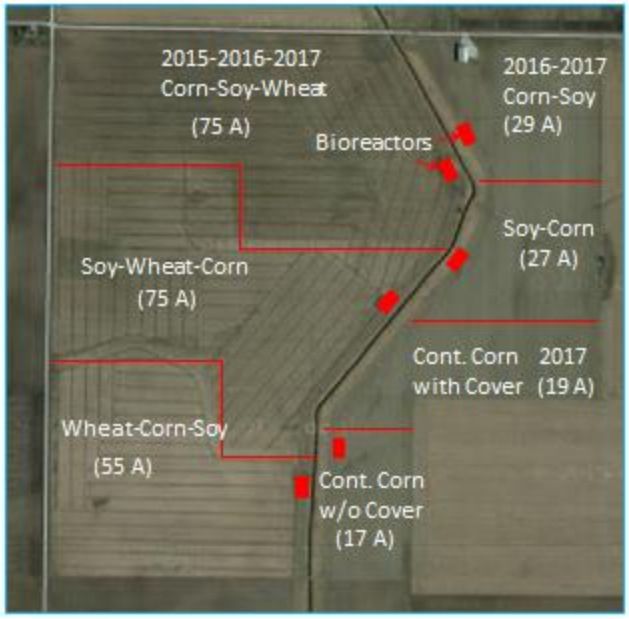
1. Determine the effect of a C-S-W rotation with cover crops on crop yields, nutrient cycling, field hydrology, and nitrate leaching on field scale plots.
2. Examine the role of cover crops in nitrogen availability and determine the N credit to the subsequent corn crop.
3. Determine field N balance and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

Length of Project

This project has completed the 3rd year of funding.

Field Design, Crop Rotation, and Bioreactor Locations

Wheat on west side in 2014 for tiling



Wheat on east side in 2015 for tiling

Location of one part of new NREC study (Cereal Rye Ahead of Corn).

N system:
50% fall/25% planting/25% side-dress
with and without cereal rye

Field Operations:

Following a wet spring, the growing season produced exceptional crop yields at this site. This site is considered to be in a mild drought at this time and there has been no tile flow since June.

Field operations for the Corn-Soybean-Wheat rotation (with cover crops):

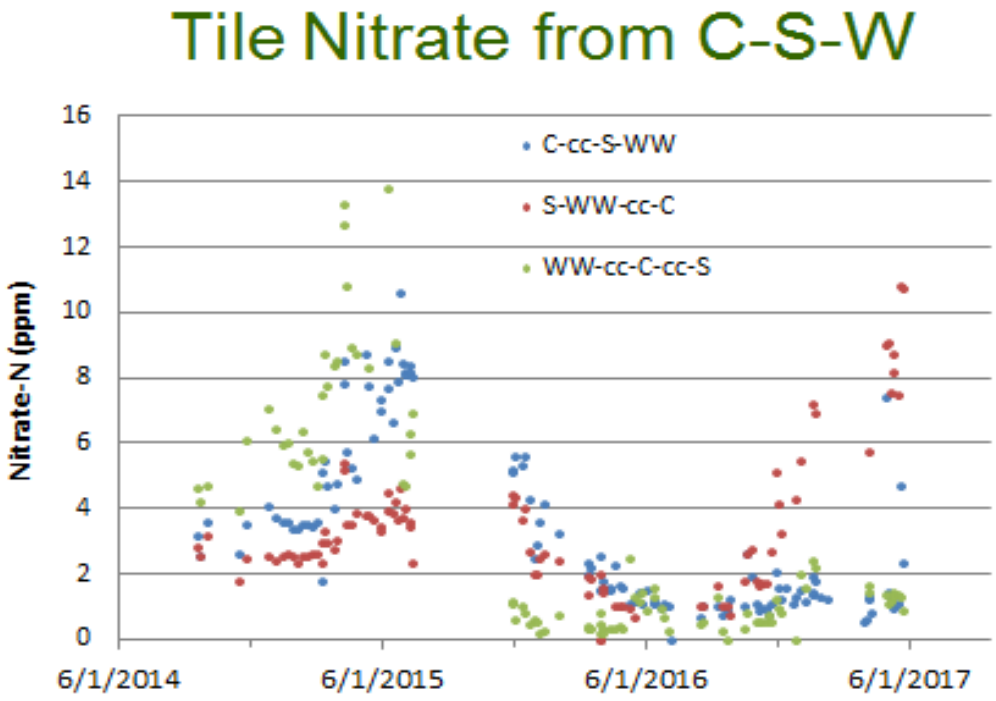
- Oct. 9, 2016: Winter wheat planted
- Oct. 12, 2016: Cereal rye planted (following red clover after wheat) ahead of corn
- Nov. 1, 2016: Cereal rye planted following corn
- Nov. 16, 2016: Strips made into cereal rye ahead of next year's corn
- Mar. 10, 2017: Top-dress N applied to winter wheat (42 lb/A)
- April 3, 2017: Top-dress N applied to winter wheat (58 lb/A)
- April 3, 2017: Termination of cereal rye ahead of corn
- April 13, 2017: Termination of cereal rye following corn ahead of soybean
- April 25, 2017: Corn planted (20 lb/A 2x2 pop-up)
- April 25, 2017: No-till soybean planted
- April 28, 2017: Soil sampled for inorganic N following red clover/cereal rye cover crop
- June 13, 2017: Corn side-dress (160 lb/A)
- June 13, 2017: Corn N rate trial established
- June 25, 2017: Winter wheat harvest
- June 27, 2017: Double crop no-till soybean planted
- Sept. 19, 2017: Corn stalk nitrate test
- Sept. 28, 2017: Soybean harvested
- Oct. 2, 2017: Applied 220 lbs/A 1240-D and 200 lbs/A of 0-0-60
- Oct. 21, 2017: No-till planted winter wheat
- Oct. 30, 2017: Corn harvested
- Oct. 31, 2017: Cereal rye drilled following corn
- Nov. 1, 2017: VRT for application of 0-46-0 and 0-0-60
- Nov. 11, 2017: Double crop soybean harvest

- Nov. 13, 2017: Applied 200 lbs/A of 0-46-0 and 200 lbs/A of 0-0-60

Field operations for the Corn-Soybean rotation (without cover crops):

- April 23, 2017: Field cultivated ahead of corn
- April 25, 2017: Corn planted (20 lb/A 2x2 pop-up)
- May 17, 2017: No-till soybean planted
- June 13, 2017: Corn side-dress with 32% N (160 lb/A)
- June 13, 2017: Corn N rate trial established
- Oct. 2, 2017: Soybean harvested
- Oct. 14, 2017: Corn harvested
- Nov. 24, 2017: Fall anhydrous ammonia applied (160 lb/A)

Results:
Tile nitrate concentrations have been greatly reduced with the longer rotation and cover crops.

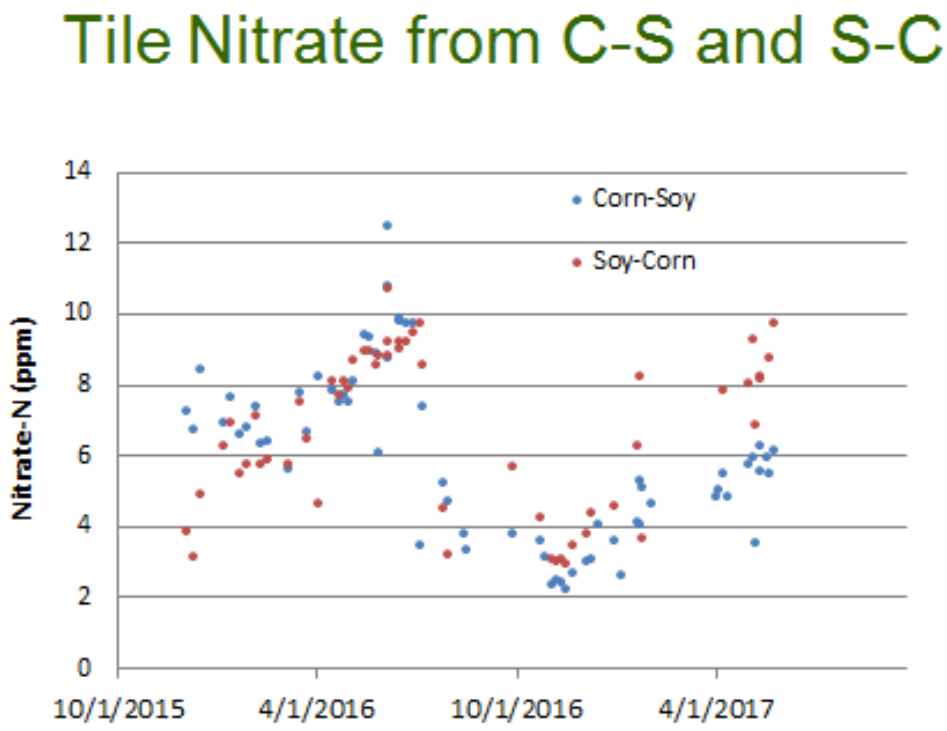


The large cover crop biomass of radish and turnip established after wheat harvest in 2015 greatly reduced tile nitrate concentrations and loads (green dots); however, the N rate trial suggested that corn needed 60 lb/A more N following the huge cover crop biomass (a total of nearly 4 tons/A). This tile has continued to remain low in nitrate during the winter and spring of 2017 as cereal rye followed corn and soybean followed the termination of the cereal rye. Tile nitrate concentration from this system has remained below 3 ppm for two drainage seasons.

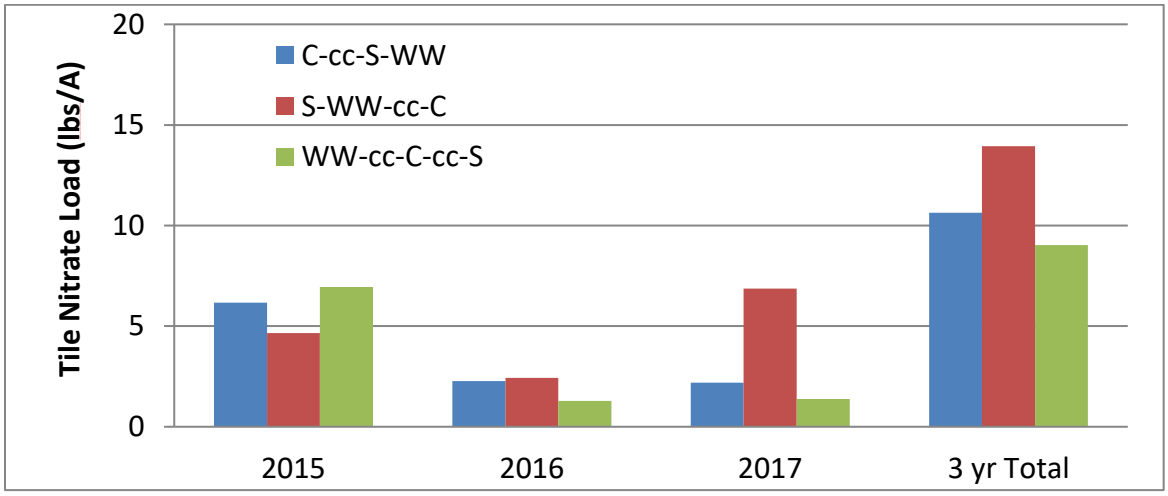
The tile draining the field with the split application of N to winter wheat (blue dots) showed an increase in nitrate concentration during two rain events this spring, but tile flow was less under wheat production.

A striking increase in tile nitrate concentration (red dots) occurred from the field that began the experiment with soybean in 2015, then winter wheat in 2016 followed by red clover (terminated August 26, 2016). Red clover biomass production (more than 2 tons/A above ground biomass) was excellent in the summer of 2016 and Mr. Miller became concerned about letting it over-winter, but was

also concerned with potential N release from the decomposing red clover. Therefore, on Oct. 12, 2016, cereal rye was planted to try to capture N from the red clover cover crop (which had approximately 130 lb of N/A in its above ground biomass). Cereal rye termination was April 3, 2017 and biomass accumulation was 0.375 tons/A; however, percent N in the biomass was high (4.7%). Therefore, cereal rye after red clover accumulated 35 lb of N/A suggesting that approximately 100 lb of N/A more N was released from the red clover than could be taken up by the subsequent crop of cereal rye.



Tile nitrate concentration from our control treatments of Corn-Soybean or Soybean/Corn show that the corn field lost more N than the soybean field.
Tile nitrate loads (lbs/A) were increased due to the early termination of red clover.



Overall, these tile nitrate losses are very low. It is clear that the longer rotation and the presence of cover crops have limited nitrate losses as compared with the control treatment (corn-soybean). However, we are more convinced than ever that tile flow has been reduced due to the back pressure on these tiles when bioreactor stoplogs are in place. There is about 2 feet of water in the bioreactors when in operation and on such flat fields we believe that tile flow has been reduced by approximately 50%. We have observed that tile base flow is eliminated from these fields due to the back pressure. This situation is similar to what occurs under

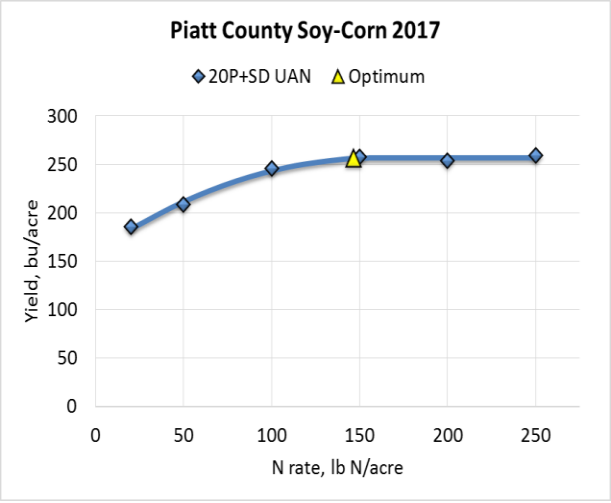
drainage water management. The fate of this retained water (tile water held back when bioreactors are in service) is unknown. Therefore, we are concerned that as much as 50% of the subsurface flow of water from the field is carrying nitrate to the ditch via lateral seepage. **We believe that bioreactor studies need to attempt to quantify the fate of the retained tile water.** This spring we plan to install 2 monitoring wells on either side of the bioreactors (parallel with the ditch) to determine the height of the water table and the nitrate in the shallow groundwater.

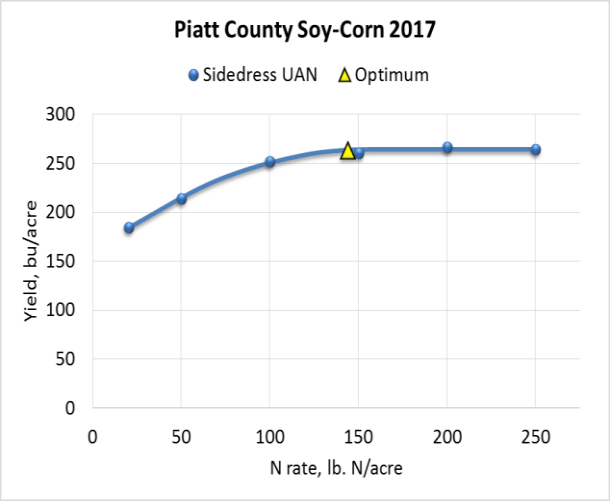
Crop yields for 2017 are below:

Crop	C-S-W	C-S
	bu/A	bu/A
Corn	259	242
Soybean	80	79
Wheat	98	-
Double Crop Soy	54	-

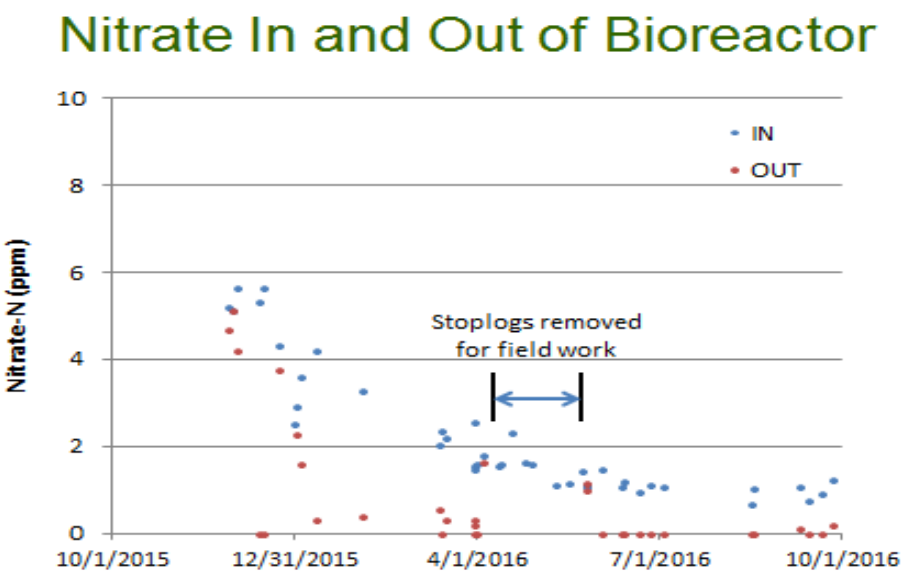
There was no yield drag with cover crops (C-S-W) compared to no cover crop (C-S) in 2017.
Crop yields were excellent in 2017 and the double crop soybean yield was phenomenal. Therefore, the economics favored the wheat/double crop soybean with profits of $35/A more than the soybean alone and $130/A more than corn. A complete economic evaluation of this study will be conducted following the 2018 harvest.

Corn N rate trials supported our overall field average yields, but revealed that there was no N credit for the red clover.

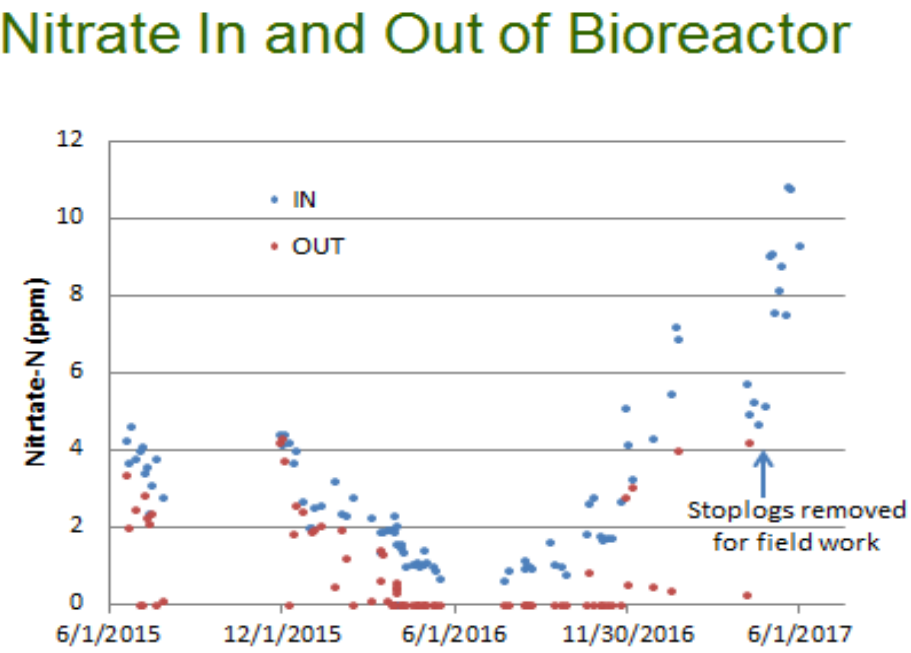




Yields for each N rate were nearly identical for both trials suggesting that the red clover N was lost from the soil. In addition, the optimum N rate was nearly identical as well.



Above is an example of bioreactor performance based on nitrate "IN" and "OUT" of the Agri Drain water level control structure. Nitrate removal is dependent on water residence time in the woodchips, amount of bypass flow, and tile water temperature. Days when nitrate "OUT" is similar to nitrate "IN" are on high flow days, especially in the winter when water is cold.



Above is another example of bioreactor performance over the past 2 years. This is the tile that was transporting high nitrate that has been released by the red clover during the past winter and spring. Overall, bioreactor performance has been good (75% nitrate removal in year 1 and 30% in year 2); however, stoplogs were removed to allow for field work in the spring and substantial tile flow and nitrate went untreated in the spring of 2017 decreasing performance (9-16% nitrate removal). Furthermore, bioreactors do not function when ditch water levels back into the bioreactor, negating the head pressure needed to push tile water through the woodchips.

Woodchip bioreactor data collection began June of 2015 and we now have 2 years of data on 3 bioreactors. With the addition of phase 2 (2 yr rotation) and phase 3 (continuous corn with and without cereal rye) at the Miller farm, we are now monitoring the performance of 6 bioreactors. Bioreactors sizes (from 250 to 1000 ft^2) are based on tile drainage areas (from 17 to 75 A) as dictated

by NRCS design parameters. We are working with the NRCS state agricultural engineer and follow NRCS guidelines for stoplog management during the fallow season as well as during the cropping season.

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.
- There was no yield drag from cover crops in 2017.
- The N rate studies were very useful in explaining differences in corn yields between the two systems (C-S-W vs. C-S). 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.

Outreach

During 2017, outreach activities included 13 invited presentations by Lowell Gentry at various events such as: the Crop Management Conferences held throughout the state; annual meetings by IFCA and LICA, and local meetings (i.e. Ford/Iroquois County Extension and the Champaign County Farm Bureau. Collectively, we estimate that >1500 people attended these meetings and conferences.

Also, Mr. Gentry presented a webinar for the Soil Fertility Seminar Series, presented 2 lectures at Parkland College, and had 2 field days this summer to present our findings from both the Douglas and Piatt County projects.

This work in conjunction with our other NREC studies has led to a cover crop guide book that was edited by Jean Payne.

2017 Project Budget ($135,373)

Expenditures		
Salary & Wages	$77,653	
Fringe Benefits	$29,955	
Materials and Supplies	$6867	
Equipment		$0
Travel		$850
Services	$8,656	
U of I Indirect Costs		$11,536
Total		$134,668
Balance	($705)	

We thank NREC for their continued support of this research. We believe this study demonstrates the potential to greatly decrease 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. We look forward to producing a thorough economic evaluation of both the 3 year rotation vs. the two year rotation at the end of this growing season.