NREC 2016 Final Report

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Illinois State University Nitrogen Management Research Farm: A Field Scale Comparison of Nitrogen Efficiency within Conventional and Alternative Nitrogen Management Systems

Investigators:

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Co-Investigator: Catherine O'Reilly, Associate Professor of Hydrogeology, Department of Geography-Geology, at Illinois State University.

Graduate Students: Michael Ruffatti and Richard Roth of Agriculture, at Illinois State University

Collaborators: Dan Schafer and Bob Fish, Illinois Fertilizer and Chemical Association

Experimental Location:

Lexington, IL is the location of the Illinois State University Nitrogen Management Research Farm. The site has been secured for a minimum of 8 years through a lease agreement with the landowners.

Specific objectives:

1. Evaluate the efficacy of conventional and systematic N management practices to reduce nitrate leaching from tile drained cropping systems

2. Investigate the impact of cover crop inclusion on the vulnerability of fall and spring applied N

3. Utilize the experimental site and research findings to educate and equip the farming community to make sound management decisions concerning N and cover crop management.

Note: This report contains only preliminary data and should not be used or shared for any purpose outside of the context of this report.

Accomplishments:

Over a three-year period (2014 set-up, 2015, 2016 experimental), this study evaluated the following nitrogen (N) management systems within a corn and soybean production system:

1. Control-No Fertilizer and No Cover crop
2. Spring Split Application of Nitrogen (20% Fall -DAP and 80% Anhydrous Ammonium)
3. Spring Split Application of Nitrogen (20% Fall-DAP and 80% Anhydrous Ammonium) + **Cover Crops**
4. Fall Split Application of Nitrogen (70% Fall-DAP and Anhydrous Ammonium and 30% sidedress- Anhydrous Ammonium)
5. Fall Split Application of Nitrogen (70% Fall-DAP and Anhydrous Ammonium and 30% sidedress- Anhydrous Ammonium) + **Cover Crops**

The above treatments allowed for the examination of two Illinois Nutrient Loss Reduction Strategy in field practices (1) move N application from the fall to the spring and (2) add cover crops to the spring N application system. In addition, the study examined an N management practice that was not listed in the ILNLRS, which is to fall apply the dominate portion of N required for optimum corn yield into a living stand of cover crops.

Table 1. Average cover crop uptake and biomass (Spring N uptake and Biomass includes both the daikon radish and cereal rye contributions).

Sample Time	Treatment	Average N Uptake (kg ha^{-1})	Average Biomass Production (kg ha^{-1})
Fall 2014	Fall N + Cover Crop	11.01	296.40
Fall 2014	Spring N + Cover Crop	9.77	236.65
Spring 2015	Fall N + Cover Crop	54.85	1052.46
Spring 2015	Spring N + Cover Crop	40.67	922.28
Fall 2015	Fall N + Cover Crop	54.86	1375.39
Fall 2015	Spring N + Cover Crop	63.86	1459.11
Spring 2016	Fall N + Cover Crop	61.21 (47% CR)	1828.53 (45%)
Spring 2016	Spring N + Cover Crop	71.11 (50% CR)	2180.72 (44%)

Over the 2-year experimental period, we determined that the timing of N application did not have an impact on the cover crop biomass production or N uptake. Although we observed a trend for biomass and N uptake production to be greater in the spring N system. This could be due to the greater residual soil N concentrations for the spring plot. The average cover crop N uptake was 63 kg ha^{-1} (56 lb A^{-1} ; 28% of the farmer's N rate), which was stabilized within the cover crop plant structure and not allowed to leach or denitrify.

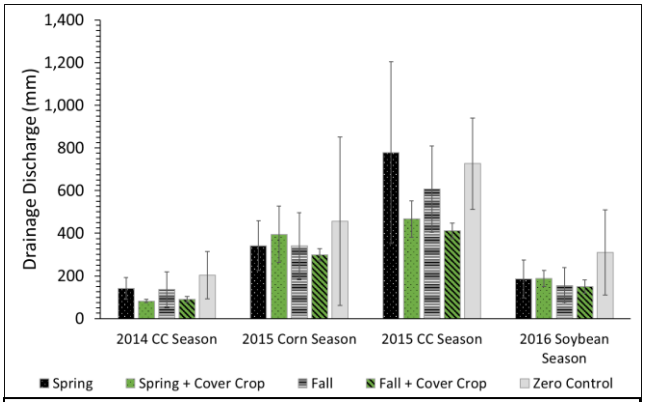

Figure 1. Cover crop impact on drainage discharge.

It was also determined that cover crop seasonally influenced the drainage discharge via tile drainage. During the cover crop growing season of each year, cover crops decreased the discharge of water from the tile system, relative to the treatments that did not contain cover crops. This reduction in tile water discharge is important and relates directly to the reduction of NO_3-N loss in the cover crop treatments. One explanation for this observation is cover crop transpiration. Cover crop transpiration could have increased the matrix potential of the soil profile, resulting a lessor soil water leaching potential.

The water quality data agreed with the science assessment of the ILNRS, demonstrating that cover crop inclusion has a greater impact on NO_3-N loading via tile drainage compared to changing N application timing. The addition of cover crops to the spring and fall N application systems resulted in a 45% and 41% reduction in NO_3-N loading (ILNLRS 30% reduction in NO_3-N loading) over

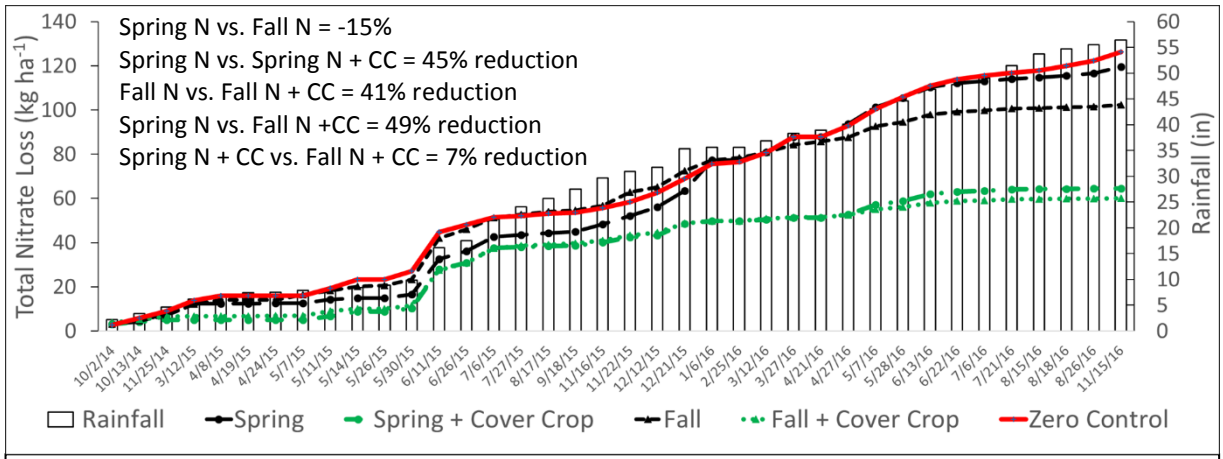

Figure 2. Nitrogen application timing and cover crop inclusion influence cumulative NO_3-N loss to tile drainage over two cash crop growing seasons (2015 corn and 2016 soybean).

two cash crop growing seasons, respectively. In addition, we learned that injecting 70% of N required into a living cover crop stand in the fall resulted in a 49% reduction in NO_3-N lost through the tile, relative to applying 80% of the required N in the spring as side-dress. When comparing the spring N +CC with the Fall N +CC treatments we observed only a 7% difference, where the spring N + CC treatments resulted in greater NO_3-N lost via the tile (ILNLRS – 10% reduction for spring N relative to fall applied N). Thus, the addition of cover crops resulted in a NO_3-N reduction of 41 to 49%, despite the timing of N application in the corn production system. One interesting discovering during the 2-year experimental period was that the zero control treatment (No nitrogen other than DAP in fall of 2015) resulted in the greatest NO_3-N loss among treatments over the two

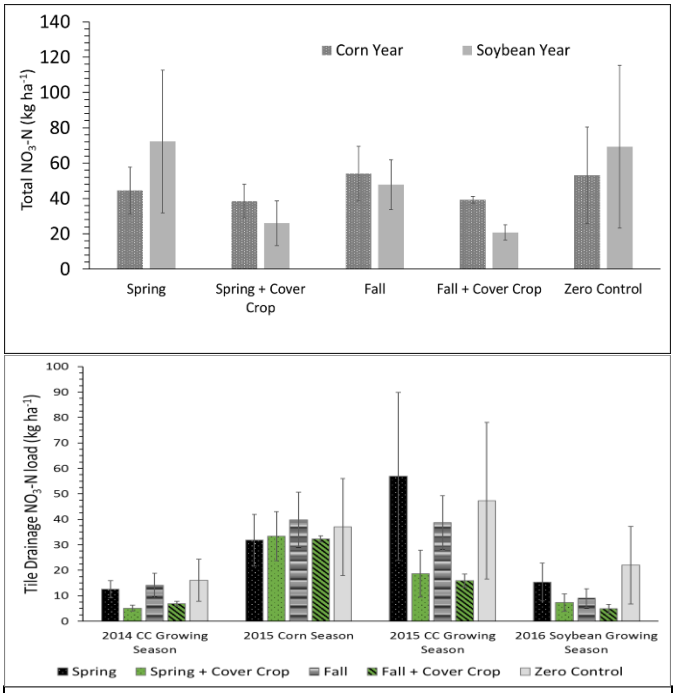

Figure 3. Total NO_3-N loss through tile drainage within the corn and soybean cropping seasons among treatments (Top). Total NO_3-N loss within cash crop and cover crop growing seasons (Bottom).

year experimental period. We hypothesize that a number of factors could be contributing to this observation. First, the experiment is conducted in a high OM soil (3.5-4% OM) and the farmer manages his residue using conservation tillage with strip-till before corn and no-till before soybean. Thus, depending on the soil and air temperature mineralization of soil organic matter could be resulting in a high concentration of NO_3-N in the soil solution without the addition of commercial fertilizer. Second, due to only a small portion of N applied in the fall in the form of DAP, the corn in the treatment are deficient of N, unhealthy, and not able to place the equivalent demand on N in the soil solution relative to the other treatments. Third, when compared to cover crop treatments the zero control treatment had no growing plant in the system placing a demand on soil NO_3-N during the fallow period of the year. Additionally, the corn N uptake and yield data that demonstrated significantly less N uptake and yield for the zero control among treatments dismisses the thought that surrounding treatments contaminated the zero control.

The analysis of total NO_3-N lost during the different cash crop growing seasons allowed us to determine which N management system has the greatest potential to lose residual N in the subsequent soybean year following a corn year. We were also able to discern the impact of the cover crops on the potential of residual N loss. Figure 3 suggest that the potential for residual N loss follows this trend Spring N=Zero Control>Fall N>Spring N +CC>Fall N + CC. Integrating cover crops during the fallow period of fertilized corn reduce the potential for residual fertilizer N being loss via tile drainage by an average of 60%. Specifically, when N application occur in the spring, cover crops reduce the potential of residual fertilizer N loss by 63% and for fall applied N by 57%. Figure 3 also demonstrates that the cover crop influence on NO_3-N loss via tile drainage has more potential to carry through from the fallow period to the cash crop growing season, when the rotation is cover crop to soybean relative to cover crop to corn. We believe that the fertilization of corn is the primarily reason that this observation exist.

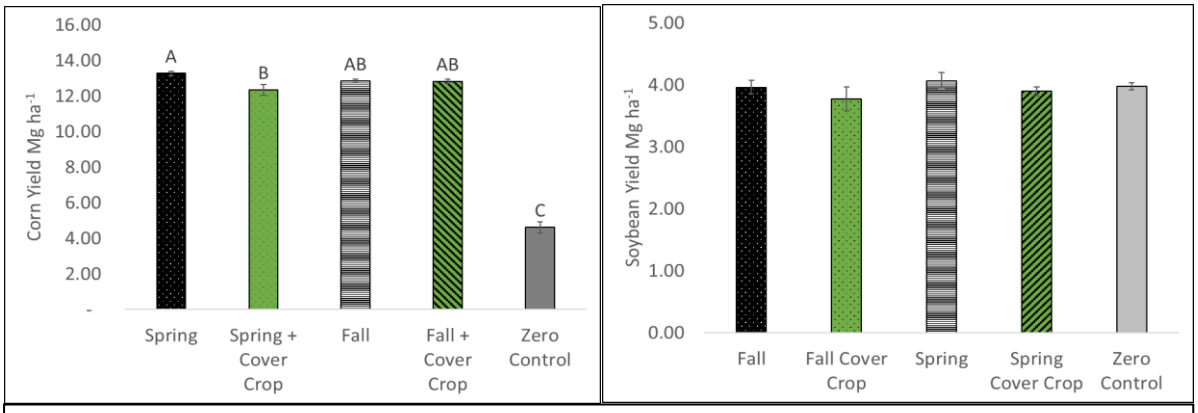

Figure 4. Corn yield 2015 and Soybean yield 2016 for all treatments.

The spring N treatment resulted in the greatest corn yield and was significantly greater than the spring N + CC treatment. However, the yield of the spring N treatment was not significantly different from the fall and fall N +CC treatments. Spring N + CC treatment yield was similar to the fall N and fall N + CC treatment.

<u>Take-Home message to farmers based upon two years of data:</u>

- On average, cover crops (cereal rye and daikon radish mixture) scavenged 50 lb N A^{-1}, which equates to approximately 18-25% of the N rates in the Central IL region.
- Despite N management system (Fall or Spring), cover crops reduced N loss via tile drainage. When cover crops were added to a spring N application system a 45% nitrate loss reduction was recorded and cover crops added to a fall applied system a 41% reduction was recorded. After two years, the nitrate lost for a spring N system with cover crops and a fall N system with cover crops was equal.
- The end-field practice of cover crops was significantly more effective in reducing nitrate loading compared to simply moving the nitrogen application from the fall to the spring.
- In a corn 2014 – cover crop (dominantly cereal rye) - corn 2015 cropping system, starter fertilizer is needed to offset the nitrogen immobilization caused by the biomass of the cereal rye. This is especially true in the spring side-dress system, but should be a rule for all systems, when cereal rye is before corn.
- Cover crop had a neutral effect on soybean yield.

Farmer Outreach/ Education Activities and Invited Presentations 2014-2016

2014

1. We participated in the NREC site tour in August 2014. Since our project was in the early phases, we participated by providing handouts and a short briefing on our watershed cover crop project at the ISU Nitrogen Management Research Farm, along with Dr. Armstrong and Mike Kelley, one of the participating farmers.
2. Illinois Field and Bean featured the project, Normal, IL
3. Indiana Certified Crop Adviser Conference, Indianapolis, IN

2015

4. Illinois Fertilizer and Chemical Association Convention Peoria, IL
5. Illinois Conservation Cropping Seminar, Sycamore, IL
6. Illinois Conservation Cropping Seminar, Mattoon, IL
7. Iowa Cover Crops Conference
8. Illinois Commodity Conference, Normal, IL
9. Illinois Conservation Cropping Seminar, Normal, IL
10. Indian Creek Watershed Project Tour, Lexington, IL
11. Soy Capital Field Day, Towanda, IL
12. FRD Radio Interview, Bloomington, IL
13. Vermilion Headwaters Kickoff Meeting, Vermilion County, IL
14. Discovery Farms and On-Farm Monitoring Multi State Meeting, Bloomington, IL

2016

15. North-Central Geological Society of America meeting, Pittsburgh, PA
16. Geological Society of America, San Antonio, TX
17. Webinar for Illinois NREC, Bloomington, IL
18. Featured in a Prairie Farmer Article
19. Midwest Cover Crop Council, Madison, WI
20. International AgroEnviron conference, West Lafayette, IN
21. Advanced Soil Health Training for Illinois Ag Professionals: Adaptive Nutrient Management for Soil Health, Sangamon, IL
22. Parkland Junior College, Champaign, IL
23. Illinois Conservation Cropping Seminar, Lexington, IL
24. McLean County Farm Bureau Agronomy Day, Lexington, IL
25. Indiana Certified Crop Adviser Day at the Purdue University SWPAC Diagnostic Training and Research Center, Vincennes, IN
26. Davis Purdue Ag Center Field day, Farmland, IN (4 presentations)
27. Indiana Certified Crop Adviser Day at the Purdue University ACRE Diagnostic Training and Research Center, Tippecanoe, IN (3 different dates)
28. 2016 Kentuckiana Crop Production Seminar, French Lick, IN
29. 2016 Corn Showcase at ACRE, West Lafayette, IN
30. Soil and Water Conservation Tour, Lexington, IL
31. Soil and Water Conservation Workshop for Chinese visiting Scientist, West Lafayette, IN
32. Illinois Fertilizer and Chemical Association Annual Convention, Peoria, IL
33. Growmark Agronomy Annual Agronomy Conference, Normal, IL
34. Proharvest Annual Cover Crop Training, Normal, IL

Financial Report:

Category	Allocated Budget	Balance after the month of February
Indirect Cost	9,540.55	0
Personal	39,890.24	0
Travel	13,521.72	7,249.34
Laboratory Commodities	20,292.75	12.67
Equipment	7,169.56	198.69
Grant Fringe Benefits	15,096.76	0