2017 Final Report Summary Sheet

Grantee Information

Project Title: A Long-term Evaluation of Nitrogen Application Timing and Cover Crops Impacts on the fate and availability of Nitrogen fertilizer and crop production on tile drained fields

Institution: Illinois State University

Primary Investigator: Armstrong

NREC Project # 2017-3-882186-86

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: One of our monitoring stations was stuck by lighting and all of the monitoring equipment at the site was destroyed.

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

If you answered "yes" please explain: We observed that cover crops (CC) reduced the mean annual flow-weighted NO_3-N concentrations of tile water by 38% and NO_3-N load by 40% when added to a fall N application system. Despite N application timing, cover crops are effective at reducing tile N losses.

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:

I have completed 23 outreach activities, published 2 manuscripts, and submitted one manuscript that is under review using data from this study.

I. A Long-term Evaluation of Nitrogen Application Timing and Cover Crops Impacts on the Fate and Availability of Nitrogen Fertilizer and Crop Production on Tile Drained Fields

II. Cooperators and Locations

Primary Investigator:

Shalamar Armstrong, Assistant Professor of Soil Conservation and Management, Purdue University, Adjunct Assistant Professor of Soil Science and Agronomy, Illinois State University and
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Co-Investigators:

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Support Scientist and Site Coordinator:

Michael Ruffatti, Department of Agriculture, Illinois State University

Project Collaborators:

Dan Schafer, Certified Professional Agronomist, Certified Crop Adviser;

Farmer and Industry Advisory Board:

Phillip Brown, Participating Farmer;
Mike Kelly, Advising Farmer and President of the SWCS;
Robert Fish, Certified Crop Advisor;
Mclean County Soil and Water Conservation Society
Illinois Natural Resources Conservation Service

Location: Lexington, IL is the location of the Illinois State University Nitrogen Management Research Field Station (NMRFS). The site has been secured for a minimum of 8 years (through 2020) through a lease agreement with the landowners.

III. Background

The contribution of nitrogen (N) from the Upper Mississippi River Basin to the hypoxic zone in the Gulf of Mexico continues to be an environmental issue and a threat to the sustainability of row crop agriculture. Due to the severity of this N loading issue, many Corn Belt states were required

by the USEPA Gulf of Mexico Hypoxia Task Force to develop a Nutrient Loss Reduction Strategy (NLRS) to reduce N and P loading by 45% by 2025. The NLRS developed by of most Corn Belt states such as IL, OH, MN, IA, and IN, concluded that cover cropping is the most effective and economically feasible in-field strategy that can be adopted on a large scale to achieve the proposed non-point nutrient loss reduction goals. However, results from recent surveys indicate that only 5% of row crop land nationally has adopted cover crops due to limiting factors such as the lack of knowledge on how cover crops affect N cycling and the fate of fertilizer N within different N management systems.

The integration of cover crops into a farmer's existing crop and N management systems requires scientists to answer three distinct questions before voluntary adoption can be considered and behavior can be adjusted: (1) Do cover crops reduce the amount of fertilizer N loss through tile drainage? (2) What percentage of cover crop scavenged N will be available to the following crop? and (3) How does the timing of cover crop residue N release correlate with the N demand of corn and soybeans? The scientific community has developed a firm understanding of the first question, namely how cover crops scavenge soil inorganic N which helps prevent N loading through tile drainage. However, no studies have quantified the second and third questions. The lack of available information on cover crop N uptake and release dynamics has made it difficult for farmers to successfully integrate cover crops into their current crop and N management systems, and as a result, the possible short-term benefits of cover crops are largely not valued.

IV. Objectives

The original research objective (1) has been executed for the last three years and will remain the primary objective. Over the next three years, objectives (2-6) will be achieved to extend our examination of N cycling by including an atmospheric N loss component (gas sampling), N fate analysis using the 15N isotope methodology, and an evaluation of the economic benefits and risks of cover crop inclusion.

Specific objectives:

1. Quantify the impact of N application timing (fall and spring) and cover crop inclusion on corn and soybean N uptake and yield, distribution of soil N, and nitrate loss through tile drainage.
2. Investigate the impact of N application timing and cover crop inclusion on N_2O release during the year.
3. Utilize ^{15}N methods to identify whether cover crops primarily take up soil or fertilizer N.
4. Determine the impact of cover crops on the fate and availability of fall and spring applied fertilizer N (mineralization, immobilization, nitrification, conversion to soil OM, leaching, and plant uptake) using ^{15}N methodology.
5. Utilize ^{15}N methods to determine the synchrony of the timing and quantity of cover crop residue N release and corn and soybean N demand.
6. Develop an economic model to evaluate the value/risk of cover crops based on five years of agronomic and environmental data.

V. Activities and Preliminary Findings

Note:

- Equipment for air sampling was installed in April, and air samples are being collected weekly to determine if there is an impact of management on N2O emissions. However, sample collecting and data analysis are ongoing, and no data from this study is in this report.
- We are in preparation and are gathering all infrastructure needed to begin our 15N analysis with the upcoming fall N application (fall 2017) as proposed.
- All methodology relating to objectives 3-5 have been established in the fall of 2017, which positions our group well to track the impact of cover crops and N timing in the spring.

Field Activities	Corn Years 2014	2015	2017
Tile Installation	Apr-18	-	-
Cover Crop Plant Sampling	-	Apr-14	Apr-12
Cover Crop Termination	-	Apr-16	Apr-12
Soil Sampling (0-80 cm)	-	Apr-16	Apr-25
Corn Planting	May-06	Apr-30	Apr-25
Spring Sidedress with AA		Jun-04	May-31
V6 Corn Plant Sampling	Jun-12	Jun-09	Jun-15
V12 Corn Plant Sampling	Jul-02	Jul-06	Jul-06
VT Corn Plant Sampling	-	Jul-14	Jul-13
Cover Crop Planting	Sep-04	Sep-05	Sep-15
Corn Grain Harvest	Oct-11	Sep-23	Oct-09
Soil Sampling (0-80 cm)	Oct-25	Oct-22	Nov-01
Cover Crop Biomass Sampling	Nov-13	Nov-25	Nov-14
Fall Anhydrous Application	Dec-04	-	-

In the fall of 2016, cover crops were planted into a standing soybean crop with a modified high-clearance sprayer **(A)**. Soybean harvest occurred on a cereal rye/daikon radish stand **(B)**, and decomposing cereal rye following chemical termination **(C)**.

Cover crop Biomass and N uptake

Table 2. Cover crop biomass and N uptake from 2014 fall to the spring of 2017. (2014/2015 going into corn, 2015/2016 going into soybean, 2016/2017 going into corn).

	Cover Biomass (lbs A^{-1})			N Uptake (lbs A^{-1})		
Sampling Date	Fall N + CC	Spring N + CC	Average Biomass	Fall N + CC	Spring N + CC	Average Uptake
2014 Fall	296	237	266	11.0	9.8	10.4
2015 Spring	1,052	922	987	54.8	40.7	47.8
2015 Fall	1,227	1,302	1,264	48.9	57.0	53.0
2016 Spring	1,631	1,946	1,789	54.6	63.4	59.03
2016 Fall	**490**	**612**	**551**	**18.7**	**22.0**	**20.4**
2017 Spring	**2,150**	**2,012**	**2,081**	**86.2**	**67.6**	**76.9**

The analysis of the cover crop biomass in the fall of 2016 revealed greater above ground biomass (122 lb A^{-1}) and N uptake (3.8 lb A^{-1}) for the Spring N cover crop treatment relative to the Fall N cover crop treatment. This difference could be attributed to greater residual soil inorganic N in the early fall when N fertilizer is applied in at side dress in the previous corn year. There was no difference in the biomass produced in the spring of 2017; however, there is a drastic difference (18.6 lbs N A^{-1}) in the cover crop N uptake. Greater N uptake for the Fall N cover crop treatment is evidence that the cereal rye in the spring is interacting with the fall-applied anhydrous ammonia that was applied in the fall of 2016. Due to the wet and warm spring in 2017, we experienced the greater cover crop biomass production and N uptake, relative to past cover crop growing seasons. The average cover crop N uptake equates to 38.5% of the equivalent mass of N applied as fertilizer in the corn year of the crop rotation. On average over three cover crop growing season, we have observed a 2:1 ratio of N in the above-ground shoot biomass to N the cover crop prevented from leaving the field. We believe that this estimate is an under estimation of the N cycling potential of cover crops because we did not consider the N in the cover crop roots.

Water Quality

Impact of Nitrogen Application Timing and Zero Control on Tile NO_3-N Losses

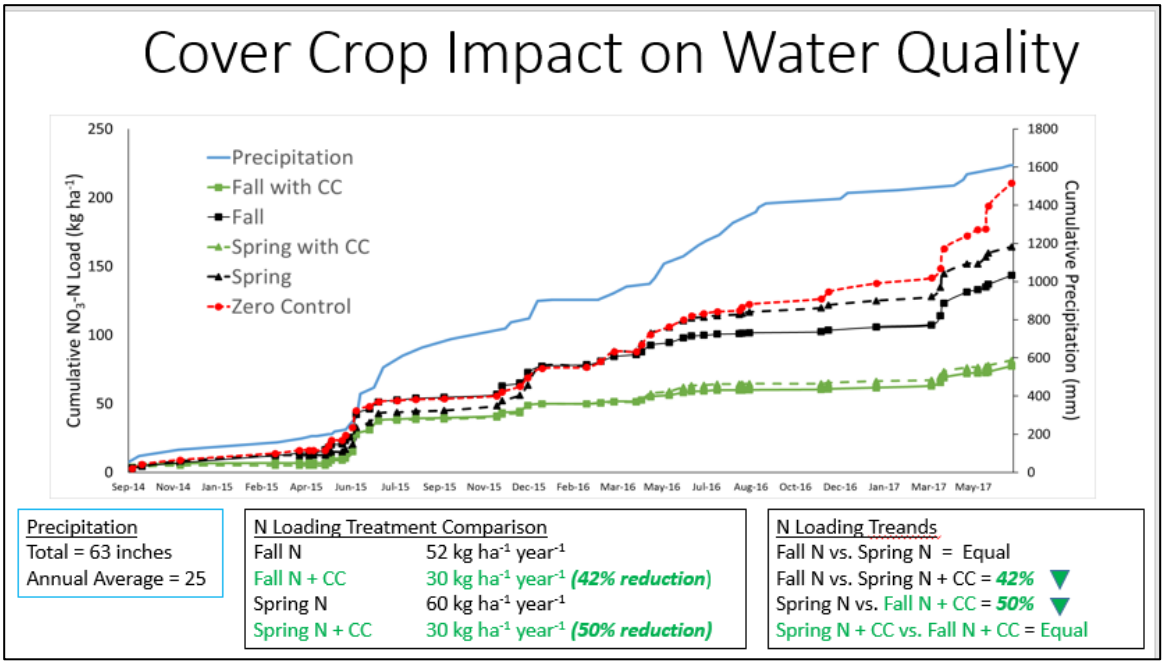
- Fall (FN) vs. Spring N application (SN): The transitioning of fall-applied N to the spring resulted in an 11% reduction in flow-weighted NO_3-N and a 25% increase in NO_3-N load over a three-year period. Specifically, when considering NO_3-N load, we observed 66% greater NO_3-N load for the SN treatment compared to the FN treatment during the soybean. This trend is corroborated by other tile-drainage studies within the UMRB that found 32% less and 88% greater N load for spring N versus fall N during soybean years.

- Zero Control (ZC) (No N applied and no cover crop): One of the unexpected observations from was the fact that NO_3-N loading via tile-drainage was similar for the ZC that did not receive N fertilizer to both the FN and SN that received the full rate of N fertilizer. This finding may be attributed to variation in tile drainage within the experimental site, although treatments were randomly assigned across the field. Other contributing factors could be that unfertilized corn plants resulted in less evapotranspiration and exerted less physical demand on the NO_3-N in the soil solution due to poor N nutrition and root development. Furthermore, high soil mineralization from a Mollisol could also be a contributing factor, seeing that 3.4 was the average soil organic matter percentage.

Impact of Cover Crop Inclusion on Spring and Fall N Application Systems

- Spring N + cover crops: In our study, combining a spring N application with cover crops resulted in a 39% and 47% reduction in NO_3-N flow-weighted concentration and load, respectively.

- Fall N + cover crops: To address N loading from Fall N application, which is common in the UMRB, one goal of our study was to compare the effectiveness of augmenting a fall N application system with cover crops to a fall N system without cover crops. We observed that CC reduced the mean annual flow-weighted NO_3-N concentrations of tile water by 38% and NO_3-N load by 40% when added to a fall N application system. However, these reductions are similar to those in spring N application systems reported in both this study and the literature. Suggesting that, despite N application timing, cover crops are effective at reducing tile N losses.



VI. Publications, Outreach, and Education Activities

Published and submitted manuscripts this NREC funded project:

Roth. R., M.D. Ruffatti, P.D. O'Rourke, S.D. Armstrong. 2017. A cost analysis approach to valuating cover crop environmental and nitrogen cycling benefits: A central Illinois on-farm case study. Agricultural Systems, DOI:10.1016/J.agsy.2017.10.007

Armstrong, S.D., R. Roth, and C. Lacey. 2017. Do Conventional Comparative Cost Efficiency Analyses Adequately Value Nitrogen Loss reduction best management practices? Agriculture Research & Technology, DOI: 10.19080/ARTOAJ.2017.12.555861

Submitted and under review:

Ruffatti, M.D., R. Roth, C. Lacey, and S.D. Armstrong .2018. Impacts of nitrogen application timing and cover crop inclusion on subsurface drainage water quality. (Submitted to Agriculture Water Management, in January, 2018)

Outreach and Education Activities

- Illinois Fertilizer and Chemical Association Annual Convention, Peoria, IL
- Growmark Agronomy Annual Agronomy Conference, Normal, IL
- Bi-State Extension Agriculture Programs, Covington, IN
- Midwest Cover Crop Conference, MI
- 3rd Annual Nitrogen: Minnesota's Grand Challenge and Compelling Opportunity Conference, MN
- Production Ag Roundtable, West Lafayette, IN
- Boone County Cover Crops Program, Lebanon, IN
- Proharvest Cover 365 Winter Forage and Cover Crop Training Meeting, Normal, IL
- Illinois NREC Nutrient Management Forum, Princeton, IL
- National Corn Growers Association 5 State Water Quality Working Group Tour, Lexington, IL
- Rulon Enterprise: The peer Network National Meeting, IN
- ISTA Agronomy Day, IN
- Benton County IN SWCD Annual Meeting, IN
- Nutrient Stewardship of Northern Illinois Field Day, IL
- Cover Crop, Nitrogen Management, and Water Quality Seminar to Brazilian Scientist, Crop Advisors, and Producers, IN
- Conservation Cropping System Initiative, IN
- American Society of Agronomy International Annual Meeting, Tampa, FL
- Indiana CCA Conference, IN
- National Cover Crop Conference, IN
- Illinois Nutrient Loss Reduction Strategy Biannual meeting, IL
- Putnam County Purdue Extension and SWCD PARP, IN
- Infield Advantage Regional Conference, IN