2021 Final Report Summary Sheet

Grantee Information

Project Title: Precision nitrogen management for improving farm profitability and water quality in southern Illinois

Institution: Southern Illinois University Carbondale

Primary Investigator: Amir Sadeghpour, Joshua McGrath. Karl Williard, Jon Schoonover

NREC Project #

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:

We have requested for no-cost extension for this project. We still have to compensate growers for using their lands.

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:

We have had difficulty accessing software from companies including AgLeader, Topcorn, Yara, Pioneer, and Monsanto. This issue still persists.

Unlike other years, we were able to fly two fields and have recently hired a graduate student with precision agriculture and remote sensing expertise to increase our capacity to fly and take images.

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

If you answered "yes" please explain:

We're are aiming to use all data collected on soil, NDVI, and corn yield to develop an initial algorithm for IL and KY. This requires more time due to massive data set collected and we will share this in a separate report with NREC.

We are assessing NDVI for predicting cover crop biomass and N accumulation. Our preliminary data are presented in this report. We hope to strengthen these predicting models in future years.

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

If you answered "yes" please explain:

A preliminary evaluation of our data indicates that (a) we could accurately predict winter cereal N uptake and (2) split N application for southern Illinois and Kentucky is more effective than upfront N management. These are shown in our report.

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:

McGrath, J.M. Multi-county talks (December 2021).
McGrath, J.M. Joint Kentucky-Indiana CCA school (October 2021).
McGrath, J.M. Invited to present to growers and consultants by Ninja Ag, LLC. "Navigating nitrogen prices while maximizing yield." (September 23, 2021). Available online at https://youtu.be/3IU6UDDatsQ.
McGrath, J.M. Ohio Agribusiness Association. "Managing fertilizer timing. OSU Northwest Agricultural Research Station. Custar, OH. (August 25, 2021).
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Sadeghpour, A., J. McGrath, Brian Arnall 2021. Popping the hood on nitrogen management. Tech Hub Live, De Moines, IW, July 20-21.
Sadeghpour, A., J. McGrath, J. Schoonover, K. Williard 2021. Precision nitrogen management of corn; next generation of cover cropping. Nutrient Research and Education Council Field Day, Carbondale, IL. July 9.
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NITROGEN RATE DECISION SUPPORT FOR SOUTHERN ILLINOIS AND KENTUCKY CORN GRAIN PRODUCTION

Project Summary

Since 2018 the KCGA has generously provided funding to support research to evaluate current corn nitrogen recommendations, develop better guidance for Kentucky farmers on nitrogen timing and rate in corn, and to develop a variable rate nitrogen algorithm guided by active optical sensors. Since 2019, we have conducted this research in cooperation with researchers at Southern Illinois University with funding provided by the Illinois Nutrient Research and Education Council (NREC) generated by Illinois fertilizer checkoff funds. We are excited to report that in 2021 we tested a new equation to guide variable rate nitrogen application that was developed using results from previous years.

Project Methods

Our current study design has evolved since 2018. We use a plot and subplot structure that is unique and meant to determine the spatial variability in nitrogen response across project fields. We established all Kentucky research plots on farmer fields in cooperation with farmers – not on UKY research station property. For 2021, we established three Kentucky sites and two Illinois sites. One site had two cover crop treatments (rye cover versus no cover), one site had a rye cover crop, and three sites with no cover crop. In addition, the study included one irrigated site. Cooperating farmers provide the seed and we planted according to their population and depth recommendations. We controlled all nitrogen inputs and harvested plots. Cooperating farmers handled all other crop management.

In 2021, we had two components to the nitrogen treatment structure. One component to evaluate a preplant-only strategy (with six treatments) and the other to evaluate a split application strategy (with 21 treatments). Table 1

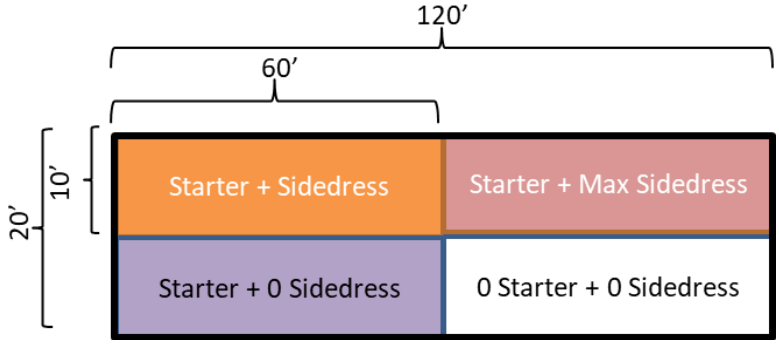

Figure 1. Sub-plot schematic with four sub-treatments that provide "bookends" of nitrogen response across the entire field.

Table 1. Preplant and sidedress nitrogen rates used in the split-application strategy portion of the study.

At planting nitrogen rate		
----------lb-N/a----------		
18.5	37.0	55.5
Sidedress nitrogen rate		
----------lb-N/a----------		
48	45	42
95	90	85
143	135	127
190	180	169
238	225	212
286	269	254
333	314	296
Total final rate		
----------lb-N/a----------		
66	82	98
114	127	140
161	172	182
209	217	225
257	262	267
304	306	309
352	351	352

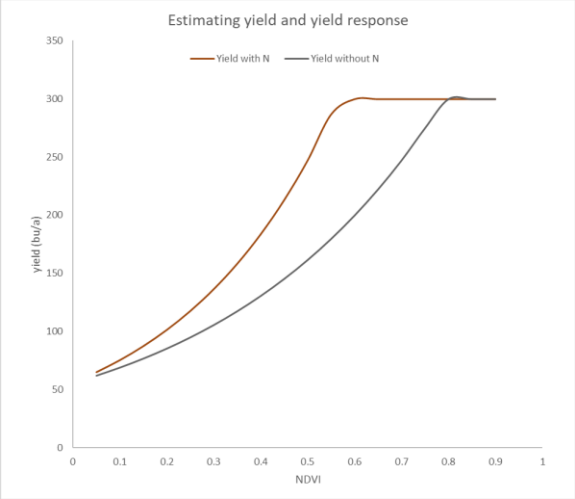

Figure 2. Fertilized and unfertilized yield predicted by equation based on NDVI from sprayer mounted sensors assuming a response index of 1.4, sidedressing 25 days after planting, and a farmer-defined maximum yield of 300 bu/acre.

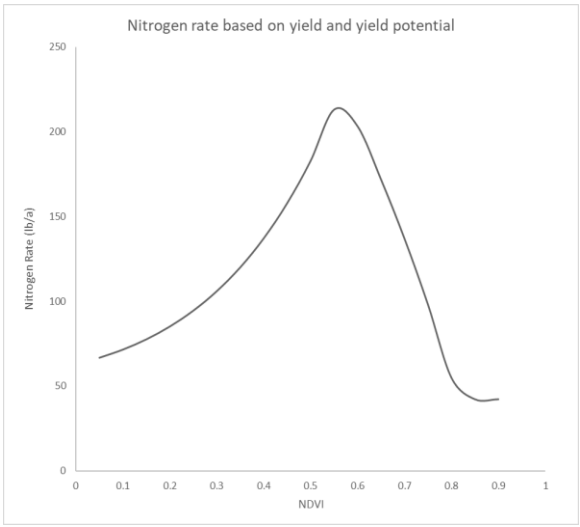

Figure 2. Nitrogen rate for any given NDVI value using the parameters from Fig. 1 and an assumed preplant nitrogen rate of 37 lb/acre.

shows the combination of starter and sidedress rates in the split strategy and their resulting total nitrogen rate. For the split portion of the study, we applied UAN at planting in a two-by-two band using the planter. For the sidedress treatments, we dribbled UAN down the center between the cornrows using drop hoses and high clearance sprayer between V8 and V12. The preplant only portion of the study had six rates applied at planting from 105 to 352 lb/acre of nitrogen. We applied the preplant treatments as UAN surface-streamed using a spray boom mounted on the back of the planter during planting operations.

Our study uses a unique subplot treatment structure. We randomly assigned one of the 27 nitrogen treatments to each main plot, which measured 20' by 120'. We replicated each treatment at least five times in each field. We then randomly assigned four sub-treatments to the 10' by 60' subplots contained in each main plot (Figure 1). The sub-treatments included:

i. Treatment starter rate + Treatment sidedress rate
ii. Treatment starter rate + no sidedress nitrogen
iii. No starter nitrogen + no sidedress nitrogen
iv. Treatment starter rate + sidedress to reach 351 lb/acre total

This sub-plot treatment includes the maximum total season nitrogen rate and a 0-nitrogen check in every plot. On a site with five replications, there would be 135 plots and as a result, 135 subplots spread across the field that received no nitrogen. This structure allows us to know the maximum yield with nitrogen, minimum yield with nitrogen, and the amount of yield gained with sidedress over starter only for each spot in the study.

In 2021, we tested the new Kentucky-Southern Illinois variable rate nitrogen (VRN) equation. Each replication randomly a strip across the entire length of the plot area (roughly 1000' long depending on the site) for each of the starter rates (18.5, 37.0, and 55.5 lb/acre). At sidedress we applied VRN nitrogen to these strips according to our VRN equation using NDVI input from the sprayer-mounted GreenSeeker sensors. The equation takes input from the sensors as normalized difference vegetation index (NDVI) to predict yield with nitrogen and yield without nitrogen (Figure) in real-time while sidedressing corn. The general approach of the VRN equation uses the difference between these two values and the grain nitrogen content along with an assumed fertilizer use to generate a nitrogen recommendation every second as you travel across the field. Figure 3 provides an example of how the equation varied nitrogen rate as a function of NDVI at one site in 2021. We used sprayer-mounted sensors

to manage nitrogen "on the go" but might be successfully applied to images collected by satellite or aircraft close to sidedress time. We are generally happy with the equation but anticipate making adjustments after we see this year's yield results.

Through 2020, we generated over 7,000 data points (at the subplot level) from 64 site-year-cover crop-starter nitrogen combinations. On average, the split-applied strategy beat the pre-plant only strategy, the average agronomic optimum yield occurred at 212 bu/acre with 234 lb/acre nitrogen, and 37 – 55 lb/acre preplant nitrogen in the 2 by 2 was adequate to get to sidedress post-V6. However, Figure 4 shows all of the data points through 2020 from sites that fit yield response models. Using corn price of $5.54/bu and nitrogen price of $0.94/lb the average economic nitrate rate (the rate that produces the most profitable relationship between nitrogen rate and yield) was 192 lb/acre at a yield of 208 bu/acre. Clearly large amounts of variability in response exists at each site. Over the 64 site-year-cover-starter nitrogen combination, the minimum agronomic optimum yield occurred at 151 bu/acre and maximum at 299 bu/acre. This leads us to the conclusion that site-specific strategies like yield goal, sensor guided VRN, or image guided VRN have value.

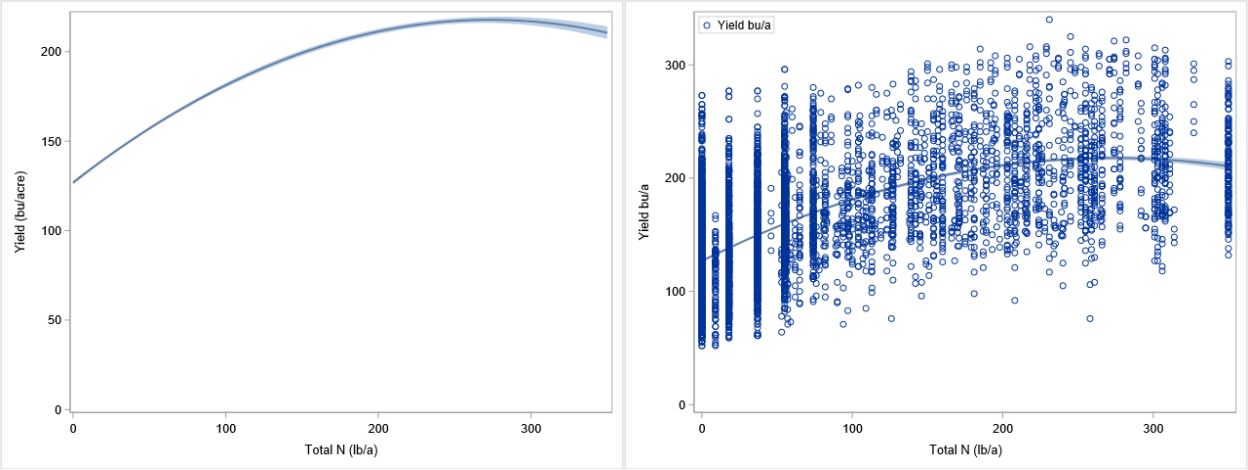

Figure 3. The average relationship between yield and total season nitrogen rate (left) and individual subplot data (right) used to make the average figure. Notice the range of yields achieved with no nitrogen fertilizer.

Apart from our proposed trials we have conducted several N rate trials that will serve as validation trials for our preliminary algorithms. These trials are conducted in Carbondale, IL (three trials) and in Belleville, IL (1 trial). These trials have cover crops and fallow treatments with multiple N rates and will help us to test our algorithm for fallow and multi-species cover crop scenarios. Through conducting these trials (on-going since 2018), we have been able to estimate winter wheat and winter cereal rye N uptake using NDVI. Preliminary data for those are included below. We hope to improve these prediction models as we move forward with our trials.

Estimating winter wheat and winter cereal rye

We took NDVI measurements from winter wheat and winter cereal rye during fall and spring. At each measurement time, we took biomass samples, dried those, calculated biomass production, and then sent samples for N and other quality analysis. We were able to estimate winter wheat and winter cereal rye N uptake with an acceptable accuracy (R^2 = 80). These data improve if we separate the model for wheat and rye. We hope to be able to incorporate these findings into model prediction for better understanding cover cop effect on variable corn N management.

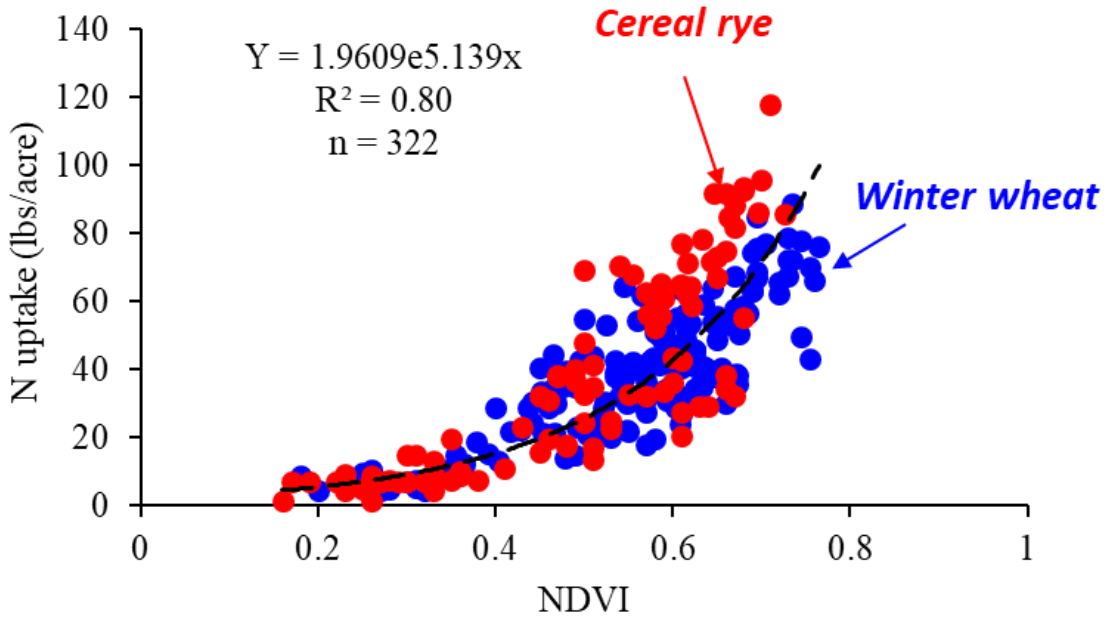

Figure 5. Estimating winter wheat and winter cereal rye N uptake using NDVI over multi-site-year studies in southern Illinois.

Outreach (Extension Talks):

McGrath, J.M. Multi-county talks (December 2021).
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McGrath, J.M. Invited to present to growers and consultants by Ninja Ag, LLC. "Navigating nitrogen prices while maximizing yield." (September 23, 2021). Available online at https://youtu.be/3IU6UDDatsQ.
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Presentations at Scientific Meetings:

Adeyemi, O., A. Sadeghpour. 2021. Effect of wheat cover crop management practices on corn nitrogen requirement. ASA, CSSA, SSSA, Salt Lake City, UT, November 7-10 [Talk].

Sadeghpour, A., O.R. Zandvakili, O. Adeyemi, J. McGrath. 2021. Precision nitrogen management of corn in southern Illinois and Kentucky. ASA, CSSA, SSSA, Salt Lake City, UT, November 7-10 [Poster].

Adeyemi, O., R. Keshavarz Afshar, E. Jahanzad, M. Battaglia, Y. Luo, A. Sadeghpour. 2020. Corn yield and nitrogen use efficiency response to cover crop and split nitrogen application. North Central Extension-Industry Conference, De Moines, IW (Virtual), Nov. 18-19 (Full paper).

Adeyemi, O., A. Weidhuner, P. Kumar, G. Singh, S. Armstrong, A. Sadeghpour. 2020. Integrating cover crops into corn production changes corn N need: Are roots the root of the problem? ASA, CSSA, SSSA, Virtual, Nov. 9-13 (Abstract).

Sadeghpour, A., Weidhuner, A.W. Kumar, P., Singh, G., Lange, R. Cover crop terminate date influences cover crop decomposition rates and corn N requirements in southern Illinois. ASA-CSSA-SSSA Annual Meeting, San Antonio, TX. November 10-13, 2019.

Journal Articles:

Adeyemi, O., R. Keshavarz Afshar, E. Jahanzad, M. Battaglia, Y. Luo, **A. Sadeghpour.** 2020. Effect of cover crop and split nitrogen application on corn grain yield and its nitrogen requirement. *Agronomy 10(8):1081*. *https://doi.org/10.3390/agronomy10081081*

Weidhuner, A., R. Keshavarz Afshar, Y. Luo, M. Battaglia, A. Sadeghpour. 2019. Sample grinding size affects nitrogen and carbon estimate of a wheat cover crop. Agronomy Journal (Online First Look). doi: 10.2134/agronj2019.03.0164