2019 Annual Report for NREC Project (2017-3-360350-314)

Cereal Rye Ahead of Corn: N catch and release

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Synopsis:

Results from currently funded NREC projects demonstrate that cereal rye following corn (ahead of soybean) has great potential to decrease nitrate concentrations and loads in tile drainage water without sacrificing soybean yield. However, cereal rye ahead of corn has been shown to reduce corn yields. A number of factors may contribute to this effect such as N immobilization, allelopathy, soil moisture and temperature, and disease. The main objective of this study is to learn how to best manage cereal rye as a winter cover crop before corn in either a corn/soybean rotation or in continuous corn. Our experimental design will accommodate three corn N fertilizer treatments (fall and spring 3 way split vs. 100% spring vs. spring and side-dress split) with and without a cover crop (cereal rye) and also with three spring cover crop termination dates (approximately 2 weeks apart). This approach will allow us to investigate plant available N under various N management regimes with and without a cover crop over a range of cover crop biomass production. We hope this study can identify the combination of management practices that generates sufficient cereal rye growth to attain the numerous benefits provided by the cover crop and still produce maximum corn yield.

Objectives:

The main objective of this study is to evaluate cereal rye as a winter cover crop before corn in either a corn/soybean rotation or in continuous corn. Our experimental design will accommodate three corn N fertilizer treatments (50% fall/25% planting/25% side-dress; 100% spring preplant; 25% planting/75% side-dress) with and without cereal rye and three spring cover crop termination dates (approximately 2 weeks apart). This design will allow us to investigate N release from the cover crop under various N fertilizer regimes and to evaluate N immobilization in regard to negative cover crop effects on the subsequent corn crop. Our overall objective is to evaluate the relationship between cereal rye biomass production and corn yields to determine what amount of the cover crop biomass leads to antagonism in corn growth.

Length of Project:

This project has completed the 3rd year of funding. The 2020 growing season will be the final year of data collection for this study.

Project Update:

This experiment has been conducted at three locations: two farms in Champaign County (Farm 1 and Farm 2) and a field at the Northwestern Illinois Agricultural Research Center near Monmouth, IL.

Field work has been delayed by wet weather this past year. Fall fertilizer N treatments were not established. Fall strip-till was not conducted. The fall fertilizer N treatment was changed to a 50:50 split of spring and side-dress N application (same situation as in 2019).

Total fertilizer N application for corn after corn is 200 lbs/A and corn after soybean is 160 lbs/A.

Field operations at Farms 1 and 2 (Corn-Corn):

- October 15, 2018: Cereal rye planted with drill
- October 28, 2018: MAP applied at 20 lbs/A of N
- April 9, 2019: Termination of cereal rye (T1); biomass collected
- April 23, 2019: Termination of cereal rye (T2); biomass collected
- May 7, 2019: Termination of cereal rye (T3); biomass collected
- May 14, 2019: Soil inorganic N sampling to 2 ft (0-1' and 1-2' by KSI from Shelbyville)
- June 2, 2019: Strips made
- June 3, 2019: Anhydrous ammonia applied (180 lbs/A for the preplant treatment; 80 lbs/A for the 50:50 split treatment)
- June 4, 2019: Corn planted (planter time treatment received 50 lbs/A)
- June 29, 2019: Side-dress anhydrous ammonia applied (100 lbs/A to the 50:50 split; 130 lbs/A to the planter time treatment for a 50-150 treatment)
- July 8, 2019: V7 corn biomass harvest
- July 8, 2019: Soil inorganic N sampling to 2 ft (0-1' and 1-2' by KSI from Shelbyville)
- November 9, 2019: Corn harvested
- November 10, 2019: Cereal rye planted with drill 63 lbs/A

Although Dr. Cameron Pittelkow has resigned, Kristin Greer is using drone flights to compare NDVI ratings with cereal rye biomass accumulation on Farms 1 and 2 and continues to measure decomposition rates of cover crop biomass using litter bags containing cereal rye residue on Farm 1.

Note: Farm 2 was too wet to plant corn by June 5 and the farmer decided to plant soybean instead of enrolling in the Prevent Plant program.

Field operations at Monmouth (Corn-Corn and Corn-Soy):

- October 3, 2018: Cereal rye planted with drill
- April 9, 2019: Termination of cereal rye (T1); biomass collected

- April 10, 2019: Strips attempted, but failed
- April 16, 2019: Anhydrous ammonia applied (200 lbs/A)
- April 23, 2019: Termination of cereal rye (T2); biomass collected
- May 7, 2019: Termination of cereal rye (T3); biomass collected
- May 15, 2019: Soil inorganic N sampling to 2 ft (0-1’ and 1-2’ by KSI)
- June 3, 2019: Corn planted
- June 18, 2019: Side-dress UAN applied
- July 8, 2019: Soil inorganic N sampling to 2 ft (0-1’ and 1-2’ by KSI)
- July 9, 2019: V7 corn biomass harvest
- October 18, 2019: Corn harvest
- October 19, 2019: Cereal rye planted with drill

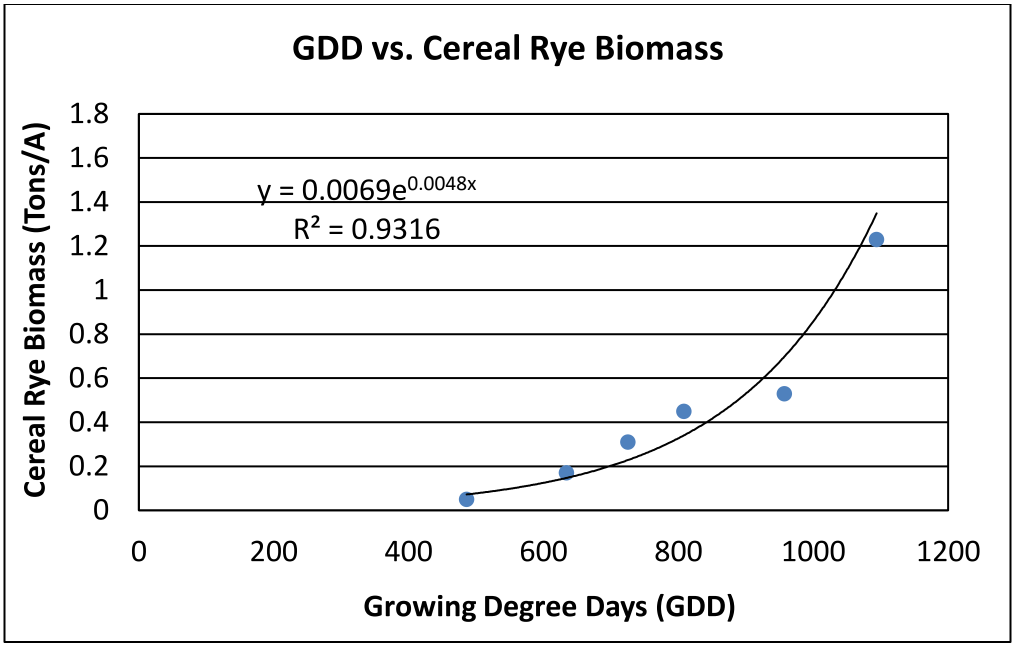
Field operations for the Corn-Corn rotation (with and w/o cereal rye) at Miller Farm:

- October 2, 2018: Cereal rye planted (65 lbs/A)
- October 30, 2018: Applied 0-100-120 to corn stubble (215lbs. 0-46-0, 200 lbs. 0-0-60) 200 lbs/A of 0-46-0 and 0-0-60
- April 16, 2019: Collected cereal rye biomass
- April 16, 2019: Termination of cereal rye with glyphosate
- July 13, 2019: Both fields were enrolled in Prevent Plant acres and were planted to a soybean cover crop at 180,000 seeds/A
- September 14, 2019: Soybean biomass harvest and then field was mowed
- October 8, 2019: Cereal rye drill planted (65 lbs/A)
- October 16, 2018: Strip till

Results:

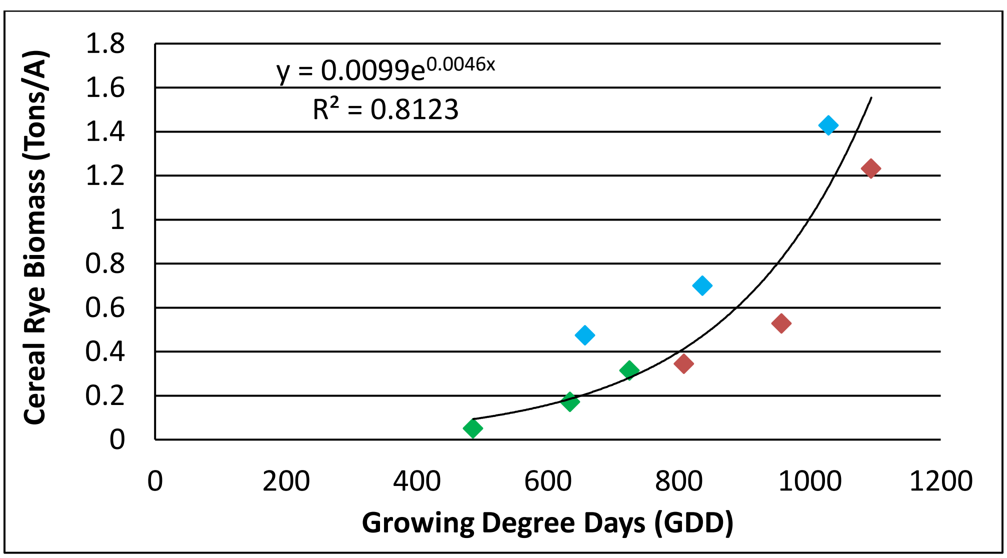
Weather delays this past fall and spring have impacted the study in regard to N treatments. The fall N treatment is now a 50:50 split between spring and side-dress. This treatment was chosen due to its success in lowering tile nitrate while maintaining high yields as determined from our replicated tile drainage study in Douglas County.

Cereal rye biomass sampling dates occurred in a timely manner this spring (every two weeks). We were able to coordinate cereal rye termination dates on Farms 1 and 2 with the Monmouth site. Cereal rye biomass was greater on a per area basis in 2019 than in the past two years due in part because strip-till was not conducted (strip-till destroys every third row of cereal rye). Thus, we can provide two cereal rye growth rates (strip-till vs. no-till) for the cover crop model that is being developed by Jonathon Coppess’s team for his NREC project.

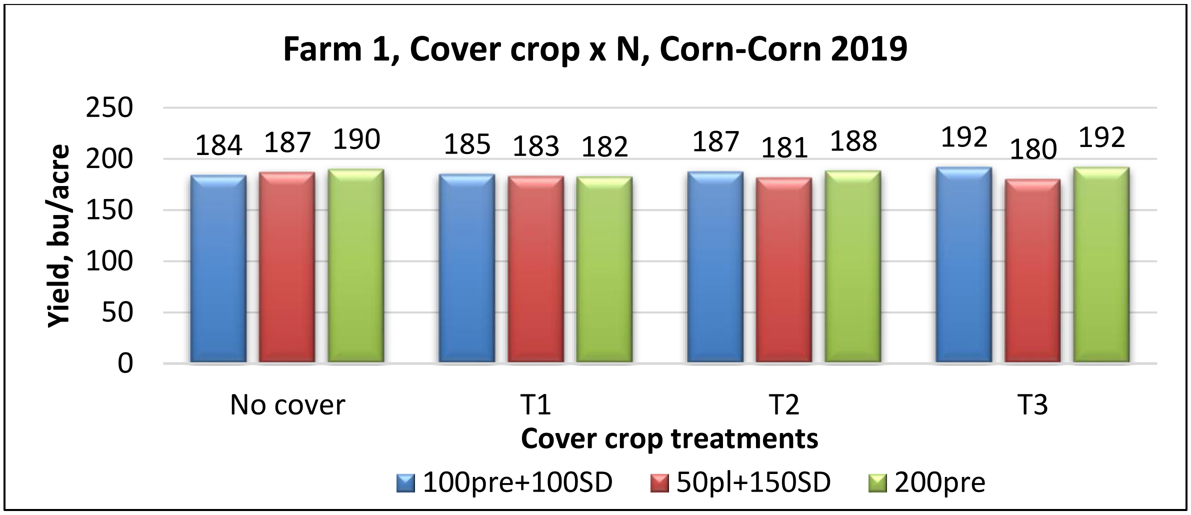


Regression of GDD and cereal rye biomass at Farm 1 in 2017 and 2018. Cereal rye biomass is the average across the 3 fertilizer N systems.

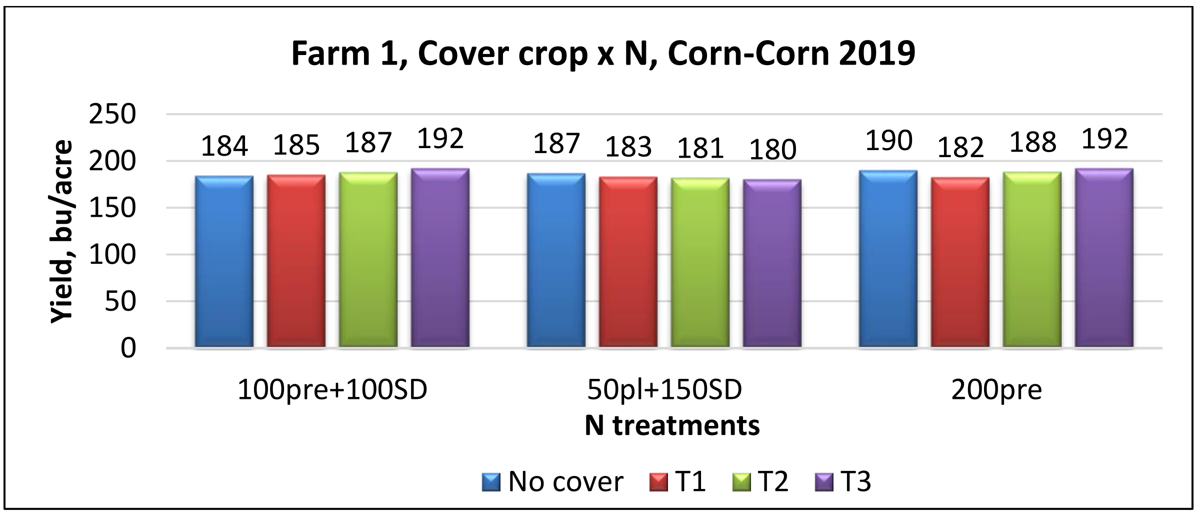
Above ground-biomass accumulation of cereal rye on Farm 1 reached a maximum of 1.2 tons/A in 2017 and 0.36 tons/A in 2018. Fall anhydrous N application appeared to stimulate cereal rye growth both years; however, modestly in 2018. With good growing conditions and the lack of strip till, cereal rye biomass accumulation was greatest in 2019 at 1.4 tons/A. A regression of GDD and cereal rye biomass accumulation across the range of GDD and biomass accumulation from the 2017 and 2018 produced an exponential curve for the growth rate of cereal rye biomass (R^2 = 0.9316). As expected, adding 2019 to this graph decreased the relationship (R^2 = 0.8123).



Regression of GDD and cereal rye biomass over the three termination dates during the past three years at Farm 1. Color indicates year (2017=red; 2018=green; 2019=blue). Cereal rye biomass is the average across the 3 fertilizer N systems.



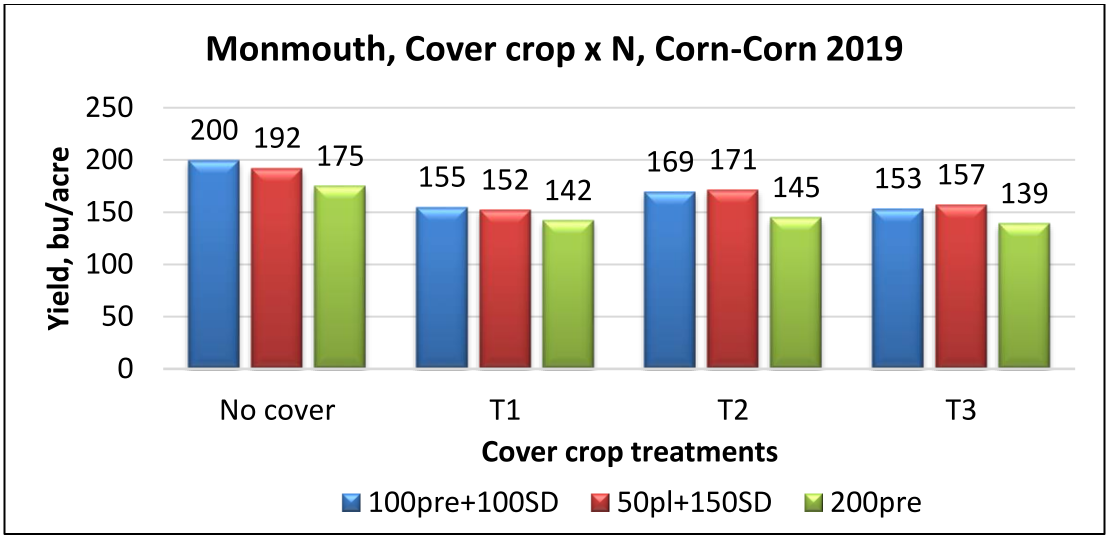
Corn grain yield across N and cover crop treatments in C-C at Farm 1 in Champaign County. T1 was 4/9/19, T2 was 4/23/19, T3 was 5/7/19, and corn planting was 6/3/19.



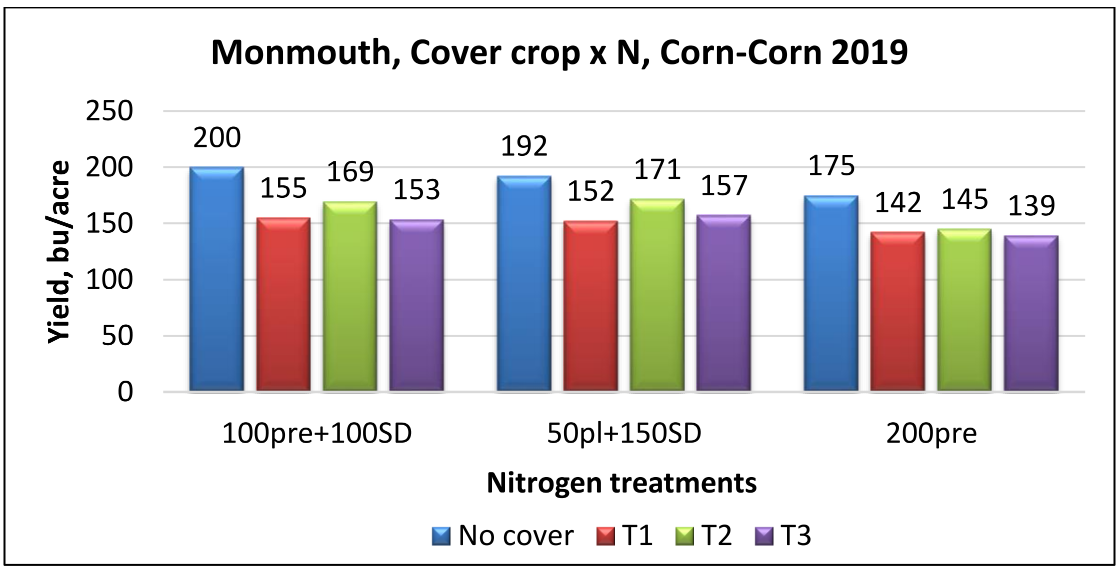
Corn grain yield across N and cover crop treatments in C-C at Farm 1 in Champaign County. T1 was 4/9/19, T2 was 4/23/19, T3 was 5/7/19, and corn planting was 6/3/19.

Based on previous years, cereal rye biomass accumulation was sufficient to decrease corn yields. However, corn planting was delayed by wet conditions following the third termination date. Termination 3 occurred on May 7, 2019 and rain fell that night. Finally, on June 2, soil was fit for strip-tillage and corn was planted the next day.

Corn grain yield was not significantly impacted by cereal rye for any given termination date. These findings suggest that the one-month delay in planting allowed enough time for cereal rye decomposition or soil N mineralization to replenish available N for crop growth. It is interesting to note that there was a trend of corn yield increase with additional cereal rye growth in the N treatment of 100 lbs/A preplant and 100 lbs/A side-dress. **These data may suggest that it takes time (multiple years) before a cover crop benefit can accrue.** Nitrogen treatments had no effect on overall corn yield; however, the late planting of corn likely decreased yield potential and muted any N management effect.



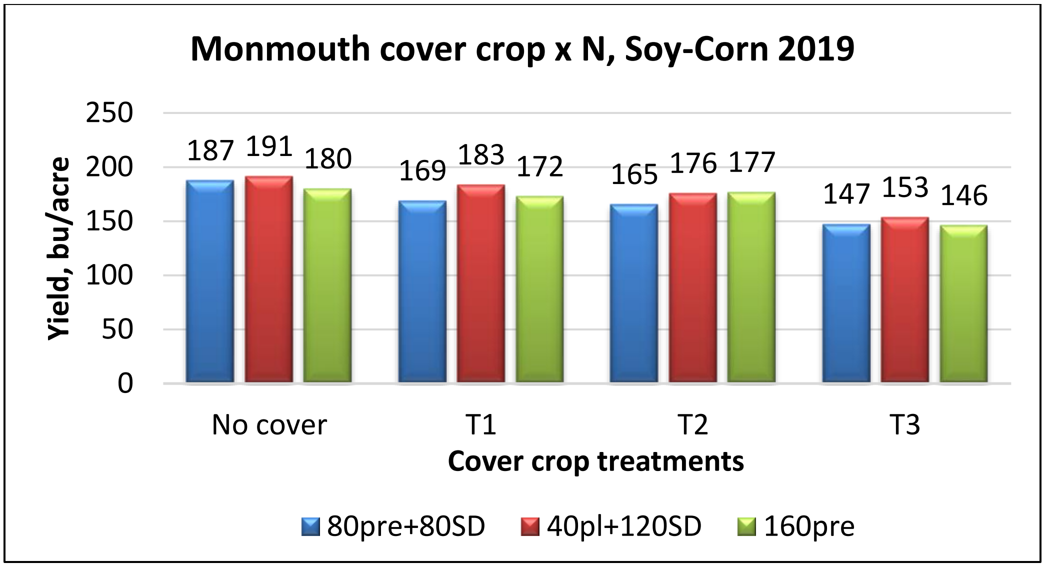
Corn grain yield across N and cover crop treatments in C-C at Monmouth. T1 was 4/9/19, T2 was 4/23/19, T3 was 5/7/19, and corn planting was 6/3/19.



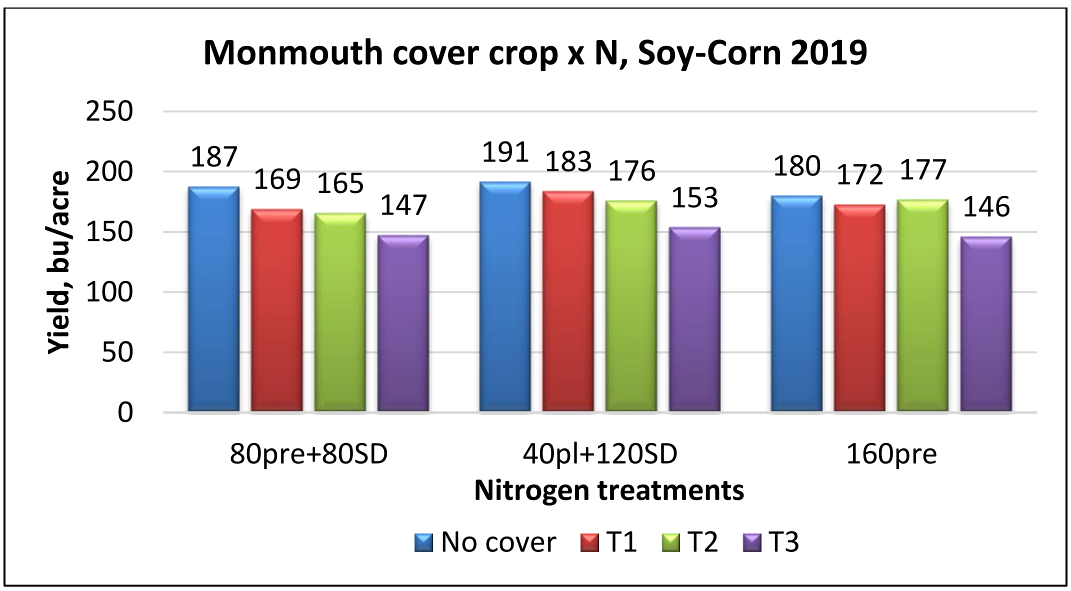
Corn grain yield across N and cover crop treatments in C-C at Monmouth. T1 was 4/9/19, T2 was 4/23/19, T3 was 5/7/19, and corn planting was 6/3/19.

As with Farm 1, corn planting was delayed nearly 1 month following T3; however, corn grain yield was significantly impacted by cereal rye regardless of termination date at Monmouth in 2019. Cereal rye growth was similar as found at Farm 1 (also in continuous corn). Note: Strip-till was unable to be performed due to wet conditions. Corn yields were reduced on average by 19% averaged across the 3 cover crop treatments compared with no cover crop.

These results clearly show that no-tilling corn into cereal rye can be problematic. Comparing Field 1 (strip-tilled) to Monmouth, we conclude that strip-tilling may be an essential tactic to avoid a yield decrease from cereal rye ahead of corn. Nitrogen treatment had a significant effect on corn yields with the side-dress treatments performing better than spring preplant. Side-dress N treatments were likely advantageous due to wet spring conditions that were conducive to N loss.



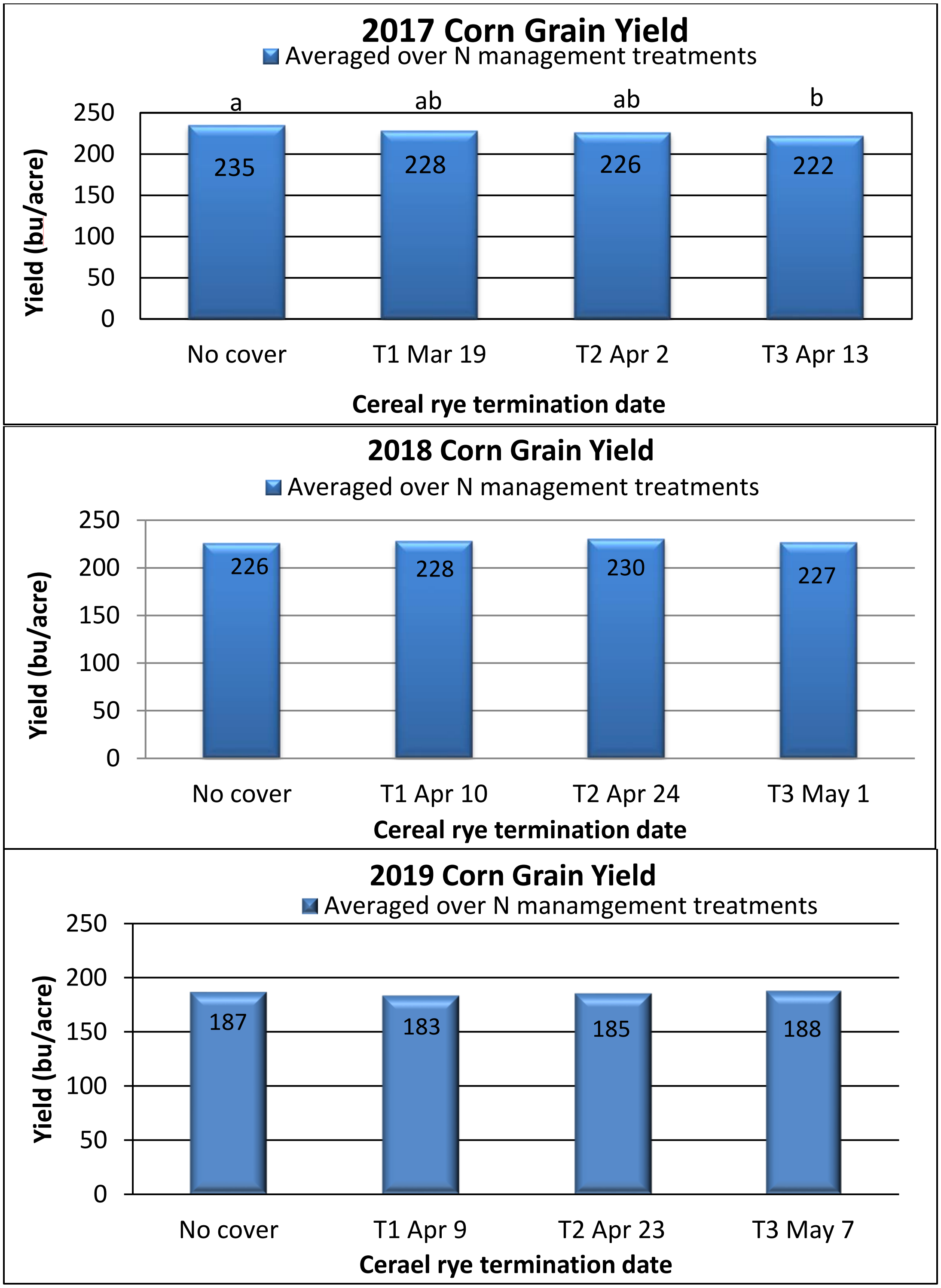
Corn grain yield across N and cover crop treatments in S-C at Monmouth. T1 was 4/9/19, T2 was 4/23/19, T3 was 5/7/19, and corn planting was 6/3/19.



Corn grain yield across N and cover crop treatments in S-C at Monmouth. T1 was 4/9/19, T2 was 4/23/19, T3 was 5/7/19, and corn planting was 6/3/19.

Field operations for S-C were performed on the same dates as for C-C plots. Similar to C-C, corn yields in S-C were significantly decreased by cereal rye. Cereal rye growth was greater following corn than soybean (especially at T3) (data not shown).in 2019. Corn grain yields were decreased on average by 14% compared with the no cover plots.

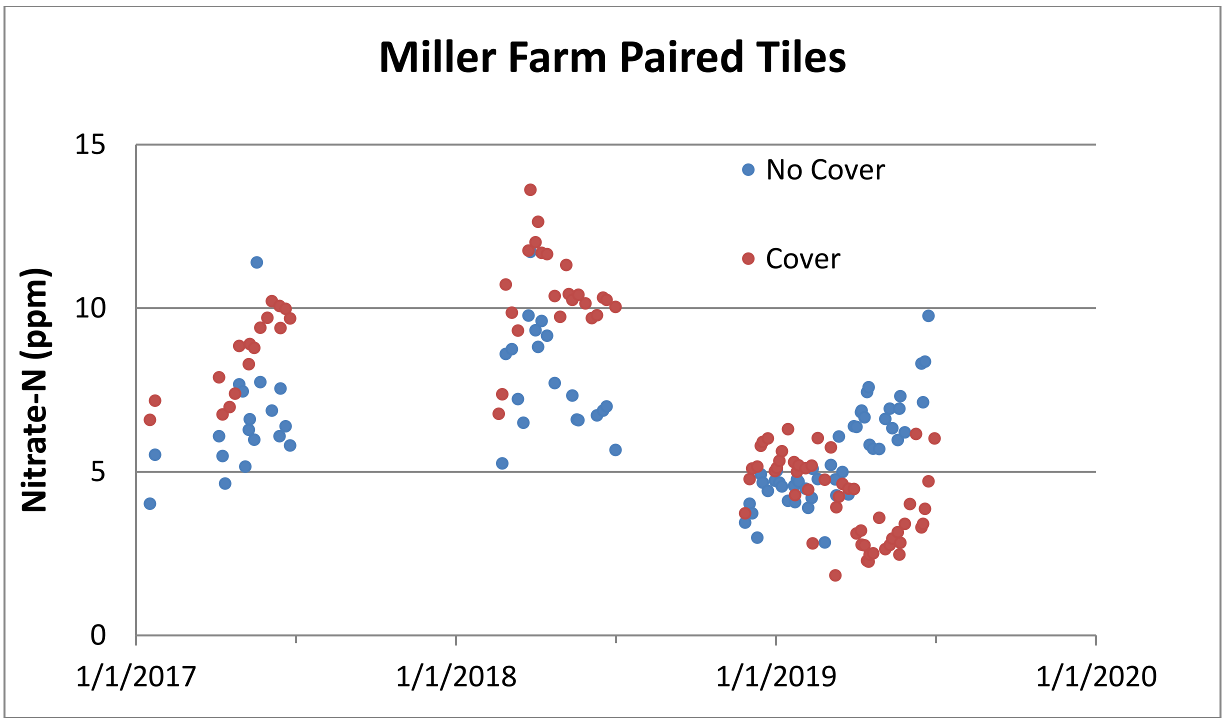
Nitrogen treatments had less of an effect on corn yields in S-C than in C-C. Side-dress N had less effect as well. Based on similar corn yields between S-C and C-C, it appears the rotation effect provided an apparent N credit of approximately 40 lbs/A.



Graphs above show corn grain yield averaged over N management treatments in 2017, 2018, and 2019 on Farm 1 in Champaign County.

An early season decrease in V7 corn biomass (data not shown) translated to a significant corn yield decrease in 2017 when comparing grain yields without cereal rye vs. late terminated cereal rye in 2017. The T3 treatment was designed to stress the system, exacerbating potential N limitations to the corn crop. This treatment produced significantly less corn grain yields (6% or 13 bu/A) compared with the no cover treatment in 2017. Although corn yield was trending down, T1 and T2 treatments did not significantly lower yield. Cereal rye biomass production was much less in 2018 and there was no effect on corn grain yield at any cereal rye termination date. In 2019, the antagonistic effect of cereal rye biomass accumulation on corn yield may have been nullified by two important factors: 1) successful strip-tillage the day before planting corn and 2) cereal rye was terminated and allowed to decompose for one-month (or more) before corn planting.

At the **Miller Farm** in Piatt County, we have continuous corn across two tile systems (paired watershed approach). Both fields received anhydrous ammonia fertilizer N in the fall of 2017; however, wet weather did not allow for fall N application in 2018. Continued wet weather in the spring of 2019 delayed corn planting past June 5 and the two fields were enrolled in the Prevent Plant program and were planted with a soybean cover crop.



Graph of tile nitrate for paired tiles at Miller Farm from January 17, 2017 through July 1, 2019. Cereal rye was planted in the fall of 2017 and 2018.

In 2018, cereal rye biomass accumulation at the Miller Farm was only 0.231 Tons/A, whereas, the warmer spring temperatures in 2019 produced 0.616 Tons/A of cereal rye biomass. Note: termination of cereal rye was not delayed by weather and was conducted on April 16, 2020.

In 2017, tile monitoring indicated that one tile transported water with a greater nitrate concentration than the other. The year of 2017 is used as our baseline comparison between the two tiles prior to cover crop initiation in the fall. In 2018, we saw the same relationship between the two tiles as in 2017, suggesting that the limited growth of cereal rye had no effect on tile nitrate concentration that year. In the fall of 2019, the trend continued; however, a dramatic reversal of the trend was observed beginning in March. Tile nitrate from the field with cereal rye decreased below 3 ppm while the no cover tile increased throughout the spring; starting at approximately 5 ppm and reaching 10 ppm by the time tile flow stopped in the summer.

These data clearly suggest that cereal rye growth and N accumulation was great enough in 2019 to reduce tile nitrate concentrations. With this study and our NREC studies, we can now approximately how much cereal rye biomass production is needed to impart an effect on tile nitrate. **We believe that the cereal rye cover crop needs to accumulate at least 0.5 tons of biomass per acre to reduce tile nitrate concentrations and loads.** There is a balance between allowing the cover crop time to accumulate enough biomass N to reduce tile nitrate load, but not too much biomass that interferes with the subsequent corn crop.

Soil inorganic N to a depth of 2 feet was determined prior to crop planting on all farms each year. Corn biomass accumulation and content were measured at V7 and soil inorganic N was again determined at the V7 corn growth stage at Farm 1 and the Monmouth site. Corn samples will be measured for N concentration. All soil and plant data will be summarized for the final project report. In general, we find less inorganic N in the soil as cereal rye biomass increases; **suggesting that plant (cereal rye) uptake and assimilation of N may be as important of a limiting factor for early corn growth as microbial N immobilization during cover crop decomposition.**

We continue to conduct the experiment on Farm 1 in Champaign County and at the Monmouth research and Demonstration Center. Farm 2 in Champaign County was planted to soybean due to the wet weather and corn planting delays in 2019. This site does not contain tile drainage and suffered from waterlogged conditions that reduced both cereal rye and corn growth. We decided not to continue using this site.

We share data from this study with Jonathon Coppess. His group is creating a farmer-friendly, cover crop model with the goal of predicting cover crop growth, N accumulation, and when to terminate. The data generated from the 3 termination dates allows for growth rates to be calculated. Our data from this study will be invaluable for calibrating their model of cereal rye growth. After this study ends, we are considering sampling cereal rye in our other NREC studies at 3 time periods in the spring (simulating three termination dates approximately 2 weeks apart) to continue to determine cover crop growth rate curves. In a recent discussion with Dr. Coppess, he strongly supported this idea and would gladly use more empirical data for model verification.

Outreach:

In 2019, Mr. Gentry was invited to present results from this study as well as the Douglas and Piatt County studies at numerous events including: Illinois Fertilizer and Chemical Association Conference; U of I County Extension meetings; Ohio Agri-Business Conference; Soil Fertility Webinar (which was converted into an on-line short course for continued education by CCAs); Midwest Cover Crop Council Conference; and Certified Crop Advisor/Ag Masters Conference.

Project Budget for 2019:

(NREC agreement 086302):

Personnel:	**Salary**	**Fringe benefits**
Administrative/professional	38,891.21	14,170.58
Wages	3,263.75	19.07
Total personnel	42,154.96	
Total fringe benefits	14,189.65	
Travel (domestic)	258.65	
Supplies	1,672.72	
Contractual services	28,322.31	
Facilities and administration	9,612.40	
Tuition		
Total expenditures	96,210.69	

Additional Summary of Highlights for 2019:

Cereal rye has proven to be a reliable, winter hardy cover crop that grows quickly in the spring and can reduce tile nitrate concentrations. With this study and our other NREC studies, we can now approximately how much cereal rye biomass production is needed to impart an effect on tile nitrate. **We believe that the cereal rye cover crop needs to accumulate at least 0.45 tons of biomass per acre to significantly reduce tile nitrate concentrations and loads.** Under warm winter and spring conditions when abundant cereal rye growth occurs, there needs to be at least 2 weeks between cover crop termination and corn planting, reducing the period of overlap of microbial N immobilization and crop N uptake. There is a tradeoff between allowing the cover crop time to accumulate enough biomass N to reduce tile nitrate load, but not too much biomass that interferes with the subsequent corn crop. In general, we find less inorganic N in the soil as cereal rye biomass increases; **suggesting that plant (cereal rye) uptake and assimilation of N may be as important of a limiting factor for corn growth as microbial N immobilization during cover crop decomposition.** Cereal rye ahead of corn requires timely management to maximize corn yields and minimize N deficiency. Additionally, strip tillage appears to be essential when planting corn into cereal rye. Although using cereal rye ahead of corn can maintain crop yields (compared to no cover treatments), it is inherently more risky than cereal rye ahead of soybean.

We thank NREC for their support of this study. Overall, we believe this study is greatly adding to our understanding of what it takes to successfully use cereal rye ahead of corn.