Nov. 2019 progress report - submitted to the South Dakota Nutrient Research and Education Council

Project Title: Sulfur and Nitrogen Dynamics for Rye Raised as a Cover Crop

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Project Duration to Date: January, 2018 through Nov., 2019

Summary *(as written in the original proposal)*
Cereal rye used as a cover crop in the corn/soybean rotation is increasingly popular among farmers. Rye has the advantages of being very winter hardy, keeping the ground covered and benefiting soil health while putting on rapid growth early in the spring. The rapid spring growth of rye brings into question its impact on nitrogen and sulfur availability for the following cash crop. It is well-known that rye sequesters nitrogen (N) and will generally increase N requirements for a following corn crop. For this reason, we have not advocated the use of rye ahead of corn. Rye ahead of soybeans is more robust as soybeans fix their own N so that is not a limitation; however, in work at the Southeast Farm in 2016, we observed that sulfur (S) content was lower in soybeans grown after rye when compared with control plots. This is consistent with observations we have made in previous years that soybeans following late-killed rye are sometimes slightly yellower in August as compared to control plots. We have not seen any yield loss from this, but it raises the question of whether S may be a factor limiting soybean response to the rye cover crop. As rye has demonstrated itself to be a robust and practical cover crop, there are questions that need to be addressed about the nutrients it sequesters - in this case we are particularly interested in S ahead of soybeans – but we will measure other nutrients as well. Preliminary analysis of data from the current season (2017) shows a yield response to S (applied as ammonium sulfate near emergence delivering 5 lb/ac of sulfur) for soybeans following a rye cover crop at the Southeast Farm (Peter Kovacs, personal communication).

Objectives *(as written in the original proposal)*

1.) Determine the extent of sulfur sequestration by cereal rye cover crop.
2.) Develop estimates of optimum rye burndown timing for soybean;
3.) Evaluate soybean response to supplemental S following a rye cover crop.

Results and Impacts - 2018 and 2019 Seasons to date

2018 Season. Three field trials were initiated to help meet the objectives listed above. Two of the trials (the rye seed rate trial and on-farm trials with supplemental S) were completed in the 2018 season. The third trial with burndown timing was lost due to heavy rains in June which inundated the field where the trial was located. The results for the two completed trials were included in the annual report for the Southeast Research Farm and are given below.

Seeding Rate for Rye Cover Crop Ahead of Soybeans

Ben Brockmueller*, Peter Sexton, and Brad Rops,

INTRODUCTION

Winter rye has found a place in cropping systems in the Upper Midwest due to its strong winter hardiness, easy establishment, and vigorous production of biomass in early spring growth. Winter rye has proved itself to be a viable option for growers looking to increase qualities of soil health and nutrient use efficiency through the use of cover crops. Rye, being a grass, is a nitrogen user and scavenges the soil for free nitrogen that is subject to losses in the system. Previous experience with rye has shown that it has the potential to sequester nutrients, specifically nitrogen and sulfur, ahead of the subsequent cash crop. In order to further explore this question, research has been conducted to examine different management systems that address these questions. One option is to look at optimal seeding rates of winter rye that provide the expected ecosystem services desired through the use of a cover crop, while maintaining adequate levels of soil moisture and nutrients for the following soybean crop.

METHODS

Rye (Rymin) was drilled into corn stalks on November 13, 2017 following harvest at the Southeast Research Farm. A Randomized Complete Block Design was used with 5 sets of treatments replicated 4 times. Seeding rate treatments of rye were 20 lbs/ac, 40 lb/ac, 60 lb/ac, 80 lb/ac, and a control of no rye. Rye was burned down in all plots on May 22, 2018 using a burndown herbicide (glyphosate and metolachlor). Soybeans were no-tilled into the rye the following day (May 23, 2018). Biomass of rye, duff, and soybeans were collected throughout the growing season to further track the rates of decomposition and nutrient content of the material. Rye biomass was collected on May 18 and May 24, 2018. Soybean biomass was collected on July 30, 2018 (R2) and September 10, 2018 (R6) in order to determine nutrient content of the soybeans at specific points in the growing season. Duff samples were collected on May 24, July 30, and September 10, 2018 to observe the rate of decomposition and ensuing release of nutrients into the soil. Grain harvest occurred on October 18, 2018

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and grain yield was measured using a Kincaid 8XP Plot Combine.

RESULTS

Yields for the control (no rye) treatment and highest rye seeding rate treatment (80 lb/ac) averaged 3 bu/ac more than the other treatments. However, we did not observe any linear trend showing that soybean yield was affected either positively or negatively as rye seeding rate increased.

Rye biomass in the spring was lower than expected due to a late planting date (November 13) and unfavorable growing conditions in the spring (Table 1). Due to low rye production, and therefore low rye residue amounts in 2018, it will be interesting to observe if more vigorous rye growth resulting from favorable growing conditions and an earlier planting date in the future will result in a more linear prediction of yield based on seeding rate. Additionally, further work in 2019 will explore how quickly these rye residues will decompose back into the soil and make the nutrients they hold plant available. The nutrient content of the rye residues, previous crop residues, and soybeans will be analyzed at specific points throughout the growing season to attempt to find a clearer picture of the fate of nutrients in the system and whether the soybean crop will be deficient of any nutrients caused by immobilization in rye residues.

ACKNOWLEDGEMENTS

The authors express appreciation to the Nutrient Research and Education Council (NREC) and the South Dakota Agricultural Experiment Station who supported this research.

Table 1: Observed rye residue biomass at burndown time. Rye residue samples were taken in two locations per plot for a total collection area of 6 ft^2. Rye burndown occurred on May 22, 2018 and soybeans were green-planted into rye on May 23, 2018.

Average Biomass Weights (lb/ac)	
Seeding Rate (lb/ac)	Dry Matter (lb/ac)
0	0
20	224
40	400
60	216
80	460

Table 2: Stand at harvest, moisture, test weight, 100 seed weight, and yield for soybeans no-till planted into rye residue. Rye was terminated on May 22, 2018 and soybeans were planted the following day on May 23, 2018. Five seeding rate treatments were utilized, 0 lb/ac, 20 lb/ac, 40 lb/ac, 60 lb/ac, 80 lb/ac.

Seeding Rate	Plant Population	Moisture	Test Weight	100 Seed Weight	Yield
(lb/ac)	(plants per acre)	(%)	(lb/bu)	(g)	(bu/ac)
0	151589	11.9	48.4	14.9	69.2
20	118483	11.9	49.1	16.1	66.3
40	123710	11.4	46.0	15.0	66.9
60	118483	11.5	47.4	14.7	66.7
80	121968	11.3	44.5	14.6	69.3
Mean	126846.7	11.58	47.035	15.06	67.67
CV (%)	20.9705	3.82	5.96	7.64	2.23
p-value	0.3879	0.27	0.19	0.393	0.03
LSD	NS	NS	NS	NS	2.27

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Sulfur and Nitrogen Applications on Soybeans Following Rye Cover Crop

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INTRODUCTION

There has been an increase in winter rye cover cropping in the upper Midwest due to its role in promoting soil health. One benefit of rye is its ability to take up and sequester mobile nutrients such as nitrogen and sulfur that could be lost from a system through leaching. Nitrogen and sulfur are converted into organic forms in the plant and released back into the soil as the tissues decompose. Previous experience has shown that rye has the potential to sequester nitrogen and sulfur leaving these nutrients slightly deficient in the following crop. Continued research into the burndown timing of rye informs how early before planting the subsequent crop that rye should be terminated to best match the nutrient release of rye with the needs of the crop. A preliminary study was done to assess the response of nitrogen and sulfur fertilizers on soybean yield when applied following a rye cover crop.

METHODS

This study was initiated at the Southeast Research Farm and in two different producer fields. Rye was planted as a cover crop in the three plot locations. A Randomized Complete Block Design was used with 7 fertilizer treatments replicated four times at each location. The sulfur fertilizer treatments were structured to deliver either 0, 10, or 20 lb per acre of S. Because ammonium sulfate also delivers N along with S, two treatments with urea were included to deliver an equivalent amount of N as was in the ammonium sulfate treatments. The treatments were as follows: 1) Control – no extra fertilizer applied; 2) equivalent 10 lb per acre as Urea (N only); 3) equivalent 20 lb per acre as Urea (N only); 4) 10 lb per acre of S as Ammonium Sulfate; 5) 20 lb/acre of S as Ammonium Sulfate; 6) 10 lb per acre of S as Magnesium Sulfate 7) 20 lb per acre of S as Magnesium Sulfate.

At the Southeast Research Farm location, a cover crop of Rye (Rymin) was no-till seeded using a drill on 07 November, 2017. It was then terminated using a burndown herbicide (glyphosate and metolachlor) on 18 May, 2018. Soybeans were no-till seeded on 31 May 2018. Grain harvest occurred on 29 October, 2018 and grain yield was measured using a Kincaid 8 XP Plot Combine.

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RESULTS

Yield data from the three locations is shown in Table 1. None of the locations showed any statistically significant difference in yields based on fertilizer treatments. However, there appeared to be a trend towards higher yields with more nitrogen applied. Using only sulfur instead of nitrogen as applied in Magnesium sulfate tended to average a few bushels per acre less than the treatments which contained nitrogen. While none of these differences were deemed significant at any of the three locations, it does offer insight into the role of rye in sequestering nutrients and the ability of supplemental fertilizers to provide a yield increase. This work will be continued into 2019 to provide a better snapshot of the nutrient content of soybean plants and the ability of supplemental fertilizers to bridge yield gaps that may be caused by rye's sequestration of nitrogen and sulfur.

ACKNOWLEDGEMENTS

The authors appreciate the contributions of the South Dakota Agricultural Experiment Station and Nutrient Research and Education Council (NREC) for this research and to the local producers (Christensen and Tornberg) for participating in this research project.

Table 1: Average yields for each of the fertilizer treatments at each of the three locations. The sulfur fertilizer treatments were structured to deliver either 0, 10, or 20 lb per acre of S. Because ammonium sulfate also delivers N along with S, two treatments with urea were included to deliver an equivalent amount of N as was in the ammonium sulfate treatments. The treatments were as follows: 1) Control – no extra fertilizer applied; 2) equivalent 10 lb per acre as Urea (N only); 3) equivalent 20 lb per acre as Urea (N only); 4) 10 lb per acre of S as Ammonium Sulfate; 5) 20 lb/acre of S as Ammonium Sulfate; 6) 10 lb per acre of S as Magnesium Sulfate 7) 20 lb per acre of S as Magnesium Sulfate. Rye was planted in the fall of 2018 at each location and sprayed out two weeks before planting. Soybeans were no-till drilled into rye residue.

Christensen Field		**Tornberg Field**		**SE Research Farm**	
Treatment	Yield (bu/ac)	Treatment	Yield (bu/ac)	Treatment	Yield (bu/ac)
Urea 20	66.3	Urea 20	59.2	Urea 20	61.0
Urea 10	65.3	Ammonium Sulfate 10	58.3	Urea 10	60.9
Ammonium Sulfate 20	65.1	Urea 10	57.8	Magnesium Sulfate 10	57.1
Ammonium Sulfate 10	64.7	Magnesium Sulfate 20	57.5	Magnesium Sulfate 20	56.6
Magnesium Sulfate 20	64.0	Ammonium Sulfate 20	57.4	Control 0	56.0
Magnesium Sulfate 10	62.5	Magnesium Sulfate 10	55.6	Ammonium Sulfate 10	55.8
Control	62.3	Control	55.3	Ammonium Sulfate 20	52.1
Mean	64.3	*Mean*	57.3	*Mean*	56.8
CV	7.7	*CV*	4.6	*CV*	19.5
p-value	0.894	*p-value*	0.41	*p-value*	0.94
LSD	NS	*LSD*	NS	*LSD*	NS

2019 Season. Trials with rye burndown timing, rye seed rate, and S application following rye were completed in the 2019 season at the Southeast Research Farm, as was a rye variety trial. On-farm trials with S application were completed at Arlington, South Dakota (Jesse Hall farm), and at Yankton (Yankton High School farm). Sample processing and analysis for fiber content and nutrient concentration is a work in progress.

Rye dry matter versus seed rate for 2019 is shown in Figure 1-c below. The C:N ratio for treatment is plotted on the right-hand side of the graph. Both biomass and C:N increased as seed rate increased, which will have an additive effect on the amount of residue present in the field and the length of time it takes to decompose. Soybean yields from these plots are shown in Table 1 below.

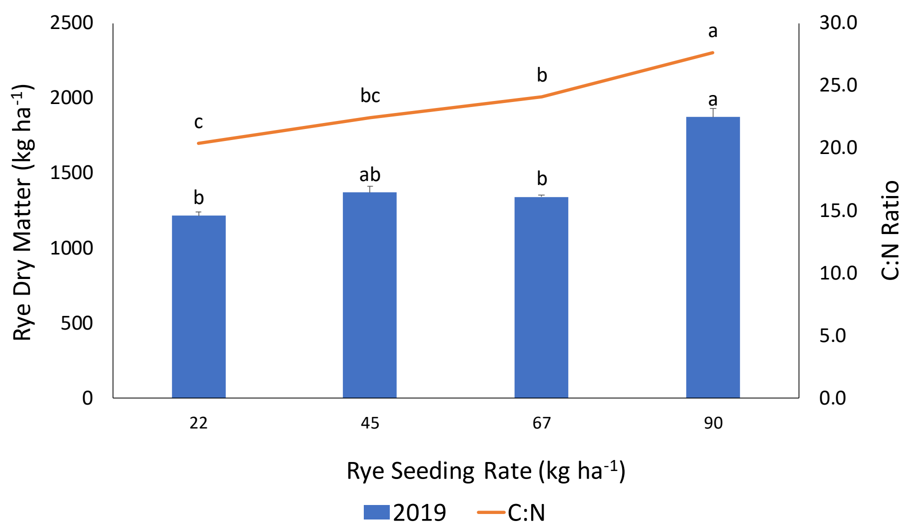

Fig. 1-c. Rye shoot dry weight and C:N ratio versus seeding rates in the range of 22 to 90 kg/ha (20 to 80 lb/ac) measured in the spring of 2019 at the SDSU Southeast Research Farm.

Table 1-c. Soybean yield following a rye cover crop at the Southeast Research Farm 2019.

Rye Seed Rate	2019 Soy Yield
(lb/ac)	(bu/ac)
0	54.9
20	56.0
40	55.8
60	55.1
80	56.6
Mean	*55.7*
CV (%)	*4.3*
LSD (0.05)	*NS*

In the trial looking at different burndown timings, rye biomass increased from 310 lb/ac on May 1 to 2530 lb/ac on May 30 (Fig. 2-c). This rapid rate of growth in May is typical for rye in our area. Samples from these plots will be analyzed for fiber and nutrient content in the coming months. We expect this project to be complete by the end of June in 2020.

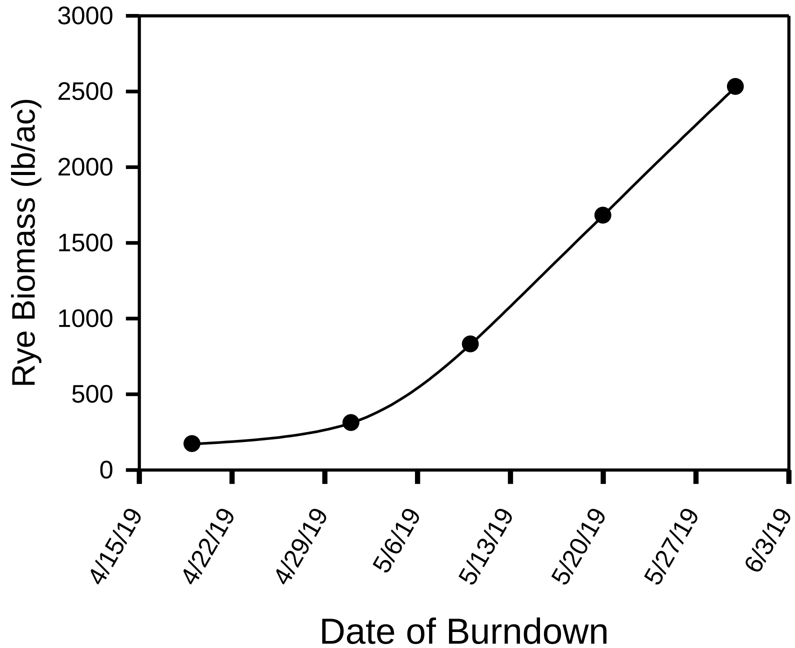

Fig. 2-c. Rye biomass versus date of burndown in a cover crop study conducted at the Southeast Research Farm in 2019. For this study, 'Hazlet' winter rye was seeded at a rate of 45 lb/ac the previous fall (Oct 2, 2018).

Changes in Project or Personnel

For the most part, the project is proceeding as planned. The burndown timing study was lost in the June of 2018 due to flooding. We were able to repeat that trial for the 2019 season. We added a small variety component to the experiment in 2019.

There are no major changes in personnel since the last update for this project. Mr. Ben Brockmueller continues to work on the project and has been doing a good job. The work has been progressing well thus far under his care.

Products (publications, presentations, disclosures/patents)

No publications have been produced at this point other than what is in the Annual Report of the Southeast Farm. An abstract was submitted and data on the rye seed rate trials in this project was presented by Ben Brockmueller at the national meeting of the ASA in San Antonio, Texas in November of 2019.

Budget Matters.

The project remains within budget. A budget extension was requested to complete the project in 2020. The project is on-going with the graduate student splitting his time between the Southeast Farm in Beresford and the USDA-ARS lab in Brookings.