Nitrogen Non-Cycling from Cover Crops Grown Before Corn and Spring Wheat-Unexpected Early Project Results

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INTRODUCTION

Nitrogen credits in North Dakota State University fertilization recommendations include those anticipated from the previous year annual legume crops (field pea, lentil, soybean, chickpea) and from terminated alfalfa. In addition, it was established in the region that sugarbeet tops returned to the soil may have an N credit potential of up to 80 pounds of N per acre (Crohain and Rixhon, 1967; Moraghan and Smith, 1994a; Moraghan and Smith, 1995a; Moraghan and Smith, 1995b; Franzen et al., 2002). Given the success of sugarbeet top N release to the subsequent crop, in theory it would be likely that any cover crop with a low C/N ratio would also provide N to the subsequent crop. Several Extension circulars and journal articles indicate that release of N to the next crop is possible if the percent N in the cover crop is greater than 1.5% (Sullivan and Andrews, 2012), a cover crop grass is sufficiently rich in N (Magdoff and van Es, 2010) or is terminated several weeks prior to planting season (Ketterings et al., 2015), or the cover crop is a legume (Gentry et al., 2013). The purpose of this on-going study is to determine the N credit from cover crops to corn and spring wheat in North Dakota.

METHODS

The 2016-17 site was located southwest of Rutland, ND, a couple miles north of the North Dakota, South Dakota border. In early August 2016, a cover crop mixture was seeded into winter wheat stubble in a long-term no-till field (>30 years continuous no-till) on Overly soils (Fine-silty, mixed, superactive, frigid Pachic Hapludolls). The cover crop was seeded as a bio-striptill, with flax, turnip, and forage radish seeded in the 30 inch row future corn row in a strip about 5 inches wide, the winter wheat was allowed to reseed and grow, and field pea was seeded every 30 inches in what would be the center in-between corn rows. On August 25, the no-cover crop plots were sprayed with 22 oz RoundupMax® and the recommended rate of ammonium sulfate solution, applied with flat fan low drift nozzles with a total spray rate of 10 gallons per acre at about 30 psi using a bicycle-mounted spray boom.

The resulting field design was a split-plot, with the main plots being cover crop or no-cover crop treatments with three replicates. On October 21, 2016, cover crops from three 1 foot by 2.5 foot areas were sampled above ground only except for turnip and radish, where the main roots were also collected, and a composite soil sample to 2 feet in depth was collected from cover crop and no-cover crop main plots. Main plots were 60 feet by 60 feet. In the spring, 6 N rates from 0-200 pound N per acre in 40 pound per acre increments were applied as ammonium nitrate May 11, 2017, 2 days following corn planting, to the soil surface. N-rate subplots were 10 feet wide by

60 feet long. In fall, 2017, 40 feet of row was harvested by hand from each N-rate plot, and the ears were shelled using an Almaco® corn sheller.

The 2017-2018 site was located northeast of Gardner, ND in the Red River Valley, about 25 miles north of Fargo. The field design was similar to that at Rutland the year before, with two main plots- cover crop and no-cover crop with subplots of 6 N-rates and three replicates. Main plots were 60 feet wide by 40 feet long, with subplots 10 feet wide and 40 feet long. On September 6, 2017, a cover crop mix of 40 pounds per acre of oat, 2 pounds of forage radish and 2 pounds of winter camelina was sown by hand into standing soybean, which had just started to turn yellow and drop their leaves (R7). Oat and radish germinated, but growth in the fall was considered minimal, so no plant samples were obtained. The no-cover crop plots were terminated with a glyphosate spraying as described previously.

The spring wheat variety Shelley was seeded May 6, 2018. The camelina in the cover crop plots survived the winter and grew to almost seed maturity before it was terminated 4 June with the spring wheat herbicide in the cover crop main plot treatments. Camelina plant stand was thin, and not evenly distributed, so no camelina plants were harvested for N analysis. Sub-plots of 6 N-rates from 0-200 pounds N per acre as Limus-treated urea were applied prior to spring wheat planting and left at the soil surface in the cover crop and no-cover crop plots. Wheat was harvested using an Almaco combine August 9.

RESULTS AND DISCUSSION

Rutland, corn after winter wheat, 2016-17.

The cover crop biomass N was 85 pounds N per acre for the 21 October 2016 sampling date at Rutland. The residual soil nitrate-N in this treatment was 15 pounds N per acre (Table 2), while the residual nitrate-N in the no-cover crop treatment was 114 pounds N per acre. The total known N (cover crop N plus residual nitrate-N) was 100 pounds N per acre for the cover crop treatment. Rye, radish, and camelina were seeded between the rows of corn 22 June 2017. On 16 August, cover crop above-ground portion of plants were sampled in each N treatment. The dry matter weight of the total cover crop was 133 pounds per acre with about 4% N, for a total uptake of about 5 pounds of N per acre.

Table 1. Cover crop biomass, C/N ratio, soil moisture to 2 feet, and residual soil nitrate, sampled on 21 October 2016, at Rutland.

Cover crop	Biomass (lbs/acre)	C/N ratio
Field pea	1490	18.1
Radish top	1690	15.4
Radish root	1370	29.8
Flax	200	21.0
Winter wheat	220	14.5
Total	4970	18.0

Table 2. Residual nitrate-N and volumetric soil water content in cover crop and no-cover crop main plots, winter wheat stubble, Rutland, October, 2016.

Treatment	Residual soil nitrate-N in 2-feet depth	Volumetric water content, inches in 2-feet soil
Cover crop	15	5.05
No-cover crop	114	5.25

Table 3. Residual nitrate-N and volumetric soil water content in cover crop and no-cover crop main plots, Rutland, 11 May, 2017.

Treatment	Residual soil nitrate-N in 2-feet depth	Gravimetric water content, inches in 2-feet soil
Cover crop	42	5.04
No-cover crop	77	5.1

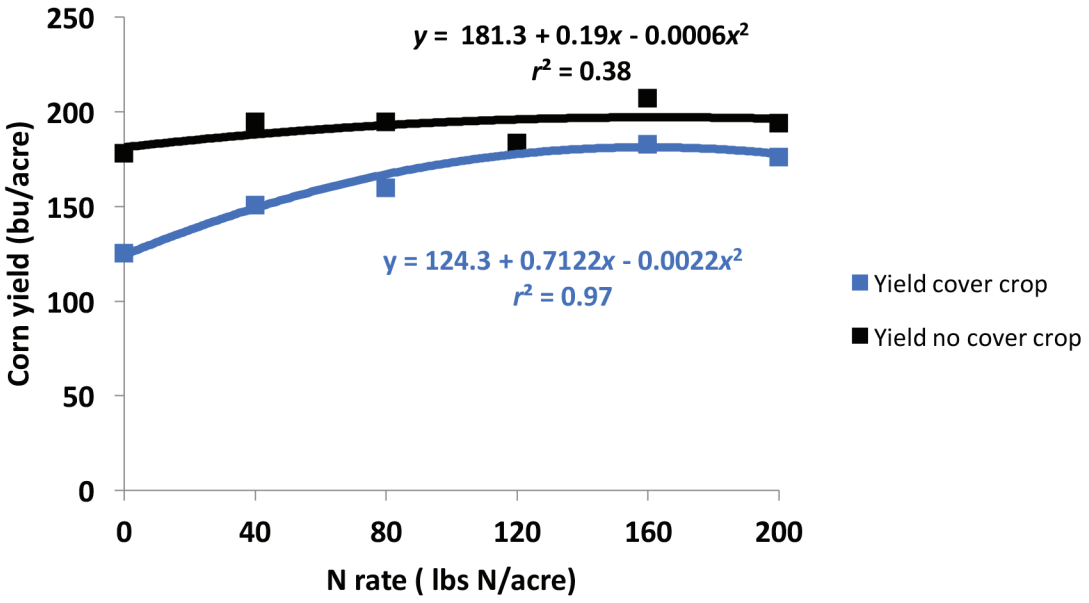

Figure 1. Corn yield after/with cover crop compared with corn yield with no cover crop, Rutland, 2017.

In only terms of corn yield, the response equations from Figure 1 indicate that N rate required for maximum yield with cover crops was 162 pounds N per acre, while the N rate required to maximize yield with no cover crop was 161 pounds N per acre. In terms of Economic Optimum N Rate (EONR), assuming $3.50 corn price and $0.40 cents per pounds of N cost, the EONR for the no cover crop was 0 pounds N per acre, while the EONR for the cover crop was 136 pounds N per acre. In terms of residual N plus N rate, the Economic Optimum N (EON, which includes

residual nitrate-N plus N rate) is 77 pounds N per acre for the no-cover crop treatment, and 178 pounds N per acre for the cover crop treatment. The cover crop had an N-drag of about 100 pounds N per acre compared with the no-cover crop, and the economic loss from cover crop was about $57 per acre due to lost yield at maximum, and cost of additional N. The reduction in yield due to cover crop could not be explained by soil moisture differences, since there were no significant differences in spring soil moisture at planting between treatments.

Gardner, spring wheat after soybean, 2017-2018

Oat and radish emerged by 29 September 2017. There was some growth before freeze-up in late-fall, but it was not considered enough to measure. Rye and radish samples obtained earlier in the year, at Rutland, 30 days after emergence resulted in about 350 pounds of dry matter per acre of both rye and radish, with a total N uptake of about 30 pounds per acre. Oat and radish did not survive the winter, although there was a scattered stand of camelina in the spring cover crop treatments prior to spring wheat seeding, but again not considered enough to measure. Measurement of surviving camelina would have been a problem, since there were often several feet between plants. Residual nitrate-N and soil moisture were similar between cover crop and no-cover crop treatments from soil samples obtained 7 May, 2018 (Table 4). Spring wheat was seeded 6 May, 2018, but no herbicide was applied until 4 June . This enabled the camelina to continue to grow until it began to set seed.

Table 4. Residual nitrate-N and percent gravimetric water in cover crop and no-cover crop main plots, Gardner, 7 May 2017 prior to seeding spring wheat.

Treatment	Residual soil nitrate-N to 2-feet depth	Gravimetric water content, % by weight in 2-feet soil
Cover crop	73	34.8
No-cover crop	60	33.7

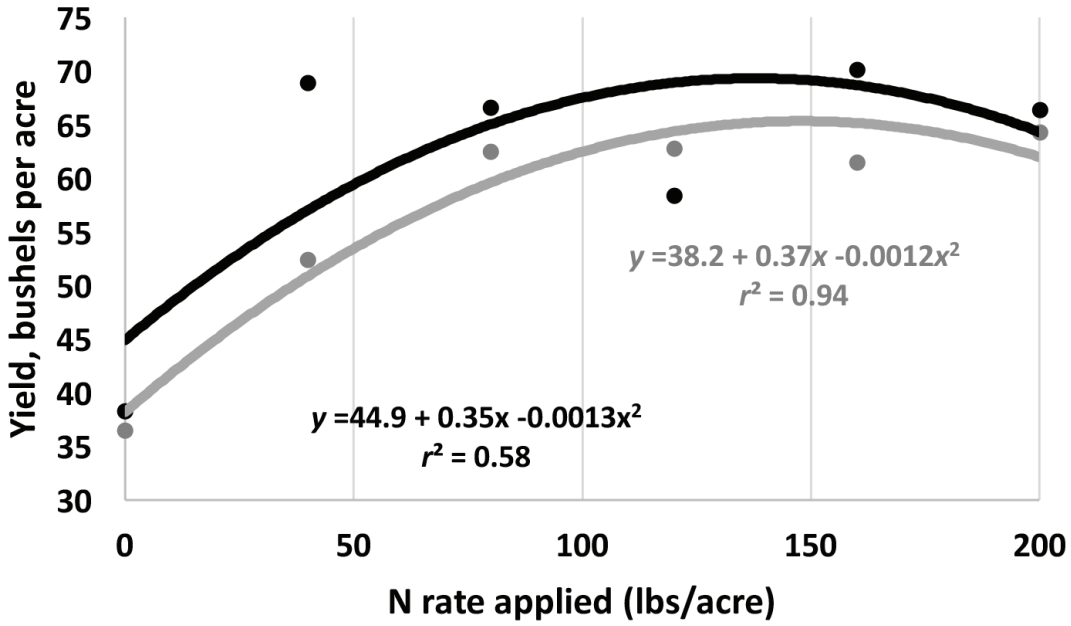

Figure 2. Spring wheat yield with cover crop compared to wheat yield with no cover crop, Gardner, ND, 2018. Bottom curve represents response to N with cover crop, top curve represents N response without cover crop.

In only terms of wheat yield, the response equations from Figure 2 indicate that N rate required for maximum yield with cover crops was 162 pounds N per acre, while the N rate required to maximize yield with no cover crop was 137 pounds N per acre. In terms of Economic Optimum N Rate (EONR), assuming $6.00 per bushel wheat price and $0.40 cents per pounds of N cost, the EONR for the no-cover crop was 111 pounds N per acre ($365.07 net return to N), while the EONR for the cover crop was 125 pounds N per acre ($341.67 net return to N).

In terms of residual N plus N rate, the Economic Optimum N (EON, which includes residual nitrate-N plus N rate) is 184 pounds N per acre for the no-cover crop treatment, and 185 pounds N per acre for the cover crop treatment. However, the 0 N rate in the cover crop treatment was about 38 bushels per acre compared with the 45 bushels per acre in the no-cover crop; a gap which the response equation indicates is about 20 pounds of N per acre N drag. The cover crop had an N-drag of about 20 pounds N per acre compared with the no-cover crop, and the economic loss from cover crop was about $24 per acre due to lost yield at maximum yield. The reduction in yield due to cover crop cannot be explained by soil moisture differences, since there were no significant differences in spring soil moisture at planting between treatments.

These data are consistent with those of Ruark et al. (2018). In a study with forage radish preceding corn, corn yields were not affected generally by the preceding radish cover crop. However, the decomposition of radish did not provide additional N to the subsequent corn crop, despite substantial N capture the previous fall. In our study, the preceding cover crop, which was a mix of forage radish, camelina, and volunteer winter wheat or oat, resulted in a yield drag to the corn and spring wheat crops that could not be overcome with additional N, as well as requiring additional N to achieve maximum corn yield and spring wheat yields.

Although as previously cited, sugarbeet tops returned to the soil during harvest of sugarbeet roots provide N to the subsequent crop. However, when the crop is abandoned, or when sugarbeet roots are applied to the soil, the result is immobilization of N for the subsequent crop (Moraghan and Smith, 2004b).

CONCLUSIONS

This project is at an early stage, but the results indicated in this paper show that just because a cover crop contains N at termination does not mean that a grower would realize an N-credit to decrease N rate. Instead, it indicates that additional N may need to be required depending on the cover crop mix and termination stage. Allowing a cover crop to grow to the maximum allowed by its environment may result in unacceptable N rate costs and yield depression in the subsequent crop.

ACKNOWLEDGEMENTS

This research was funded by the U.S. Department of Agriculture-NIFA and awarded to North Dakota Agricultural Experiment Station scientists (Award no. 2016-69004-24784,“CropSys - A novel management approach to increase productivity, resilience, and long-term sustainability of cropping systems in the northern Great Plains” www.cropsyscap.org).

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