ADVANCES IN NORTH DAKOTA SOIL FERTILITY 2022

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ABSTRACT

Following years of data accumulation from field studies using the GreenSeeker™ and Holland Scientific Crop Circle™ active optical sensors, algorithms for use in spring wheat to direct in-season N application for yield to determine the need for immediate-post-anthesis N application for protein enhancement have been developed. Both algorithms require an N non-limiting area as a standard. The algorithm for protein enhancement considers whether a cultivar has inherent high protein or lower protein characteristics than the industry standard 14% protein. Algorithms for use in determining N rate for in-season application to corn has also been modified and stream-lined.

Cover crops are becoming more common in North Dakota for use of excess moisture and to eliminate wind erosion. A summary of North Dakota studies indicated that:

1. it is difficult to produce more than 500 pounds per acre dry matter after corn or soybean, even if the cover crop is interseeded into a growing crop.
2. interseeding into corn does not produce yield drag, at least partially due to the dew that the cover crop attracts.
3. substantial cover crop dry matter (greater than 1,000 pounds per acre) is only consistently possible after short-season crops including barley, spring wheat and winter wheat.
4. N contained in cover crops is not released to the subsequent crop, even if there is a legume in a mix containing a small grain, small grain volunteers, or forage radish/turnip.
5. it is possible that the ammonium released immediately on decomposition is being ‘fixed’ by smectitic clays into a non-exchangeable ammonia fraction, which may be released several years after cover crop N accumulation.

INTRODUCTION

Active-optical sensors

In-season N application has been a part of NDSU corn fertilizer recommendations for at least 10 years. In-season N application, or side-dress, is not a state-wide recommendation although farmers across the state may choose to use the strategy for logistical help in managing their N inputs and spring help status. As in all Great Plains states, rainfall in North Dakota is greatest in the east, with decreasing rainfall the farther west one travels. In eastern ND, where spring rains may be in excess of crop needs, leaching on sandy loam and coarser soils, and denitrification on high clay soils is always a threat to the efficiency of crop N uptake. Therefore, side-dress is recommended on the soils with that history.

In dry springs, after using the ND N calculator to determine total seasonal N requirements based on residual soil nitrate to 2 feet, previous crop N credits and indicating whether the farm is in long-term (6 years or more continuous) no-till, if half of the N is applied pre-plant or at planting, the last portion can be applied by subtracting the initial N rate with the total recommended. However, in wet springs, loss of residual nitrate and the portion applied preplant/at-planting is highly possible on susceptible soils. Therefore, without some tool to indicate corn status, the N rate for side-dress is a guess. The use of an active-optical sensor was therefore investigated successfully to predict corn yield as a means to indicate side-dress N rate.

Oklahoma State University, led initially by Bill Raun and two Ag-Engineer colleagues, and now led by Brian Arnall, has maintained a website detailing the use of the GreenSeeker since the late 1990's. The initial research group developed the GreenSeeker for commercialization and correspondingly developed the science that makes its use and the use of other active-optical sensors practical (https://www.nue.okstate.edu/). Their website contains information on the development of the concept, first on Bermudagrass and winter wheat, and then on other crops.

Sensor research for application in spring wheat at NDSU was directed towards two different goals; first, to use the sensor to direct the rate of in-season N before mid-jointing to increase yield; second, to use the sensor at flag-leaf to determine whether or not a foliar N application should be applied immediately after anthesis (post-anthesis). Spring wheat in the Northern Plains of North Dakota, Montana, some portions of South Dakota and northwest Minnesota is considered a premium what by buyers interested in 'strong flour' with great gluten content. The industry standard is 14% protein. Selling hard red spring wheat with protein less than 14%, the farmer is subjected to a low protein dockage in most years (2021 excepted due to low supplies). In some years, particularly when TX, OK, KS wheat has low protein, the Northern Plains farmer may be offered a premium for spring wheat with protein greater than 14%. The dockage and premium value is always a guess until harvest time, but in some years the need for higher protein wheat is telegraphed to the farmer via news stories from the southern plains regarding their protein status and from other parts of the world. Agronomically, there is no non-sensor way to evaluated whether the farmer might reach or exceed 14% protein, thus the research effort.

Cover Crops

There is interest in North Dakota on cover crops to decrease wind erosion susceptibility in conventionally tilled systems, to reduce the loss of N at the end of growing seasons, and to reduce moisture in the spring to enable more timely planting and reduce acres lost to prevent planting. With greater corn and soybean acreage (8-10 million acres recently out of about 24 million total state acres), one challenge is establishing a meaningful cover crop after long season crops. Another question is when N is taken up by cover crops, when is it released.

METHODS

Active-Sensors

A series of N rate experiments were conducted from 2010 through 2021 on spring wheat (14 sites) and corn (58 sites). Each study was constructed as a randomized complete block design. Spring wheat sites were located in the eastern third of the state where spring rainfall might result in N loss, and where protein is more difficult to maintain market grade compared to western-grown wheat. The corn research was conducted across the state due to its longer season of N loss susceptibility and the newness of the crop in many areas of North Dakota. Each site consisted of 6 N rates from 0-200 pound N per acre in 40 pound N per acre increments with 4 replications. The GreenSeeker™ and Holland Scientific Crop Circle Sensor™ was applied at about V5 in spring wheat and V6 in corn.

Cover Crops

Cover crops were investigated from 2016 until the present year. Experiments were established near Rutland/Havana, ND on long-term (>40 years continuous) no-till fields and ENE of Gardner, ND on a transitional no-till field with high clay content. The experimental design on all experiments was a randomized complete split-plot, with cover crop and no-cover crop as main split, and N rates from 0 to 200 pounds N per acre in 40 pound per acre increments as the subplots). There were 3 replications. The study was conducted using a three-crop rotation of corn, soybean and spring wheat, in that order. There were 3 individual experiments in one larger field at Gardner, and there were 3 different fields with an experiment matching the rotation choice at Rutland/Havana. In corn, the cover crop (cereal rye + forage radish + camelina) were interseeded at about V6 using a prototype FargoAir™ (Amity Technologies, Fargo, ND) seeder. Cover crop following spring wheat included letting the spring wheat volunteers grow, seeding forage radish and camelina with a seed drill. Soybean preceded corn in this system, so interseeding in soybean was conducted usually in late August before leaves began to turn. The cover crop choice was oat, forage radish and camelina, broadcast applied by walking through the experiment in the cover crop main plots using a chest-style grass-seeder. Cover crop dry matter was determined from each main plot from 3, 1 foot by 2.5 feet areas by clipping the plants at the soil level. Radish roots were pulled and weighed separately when present. All plant samples were subjected to total N analysis by species.

RESULTS

Corn active-optical sensor algorithms

Algorithms are at https://www.ndsu.edu/fileadmin/snrs/Files/sf1176-5_0.pdf , which is a web-based publication. The algorithms support data gathered from a GreenSeeker Red NDVI sensor and from the Holland Scientific Crop Circle sensors for Red NDVI and Red-Edge NDVI if the sensor is used between V4 and V8. Readings are obtained from a preplant/at-planting N sufficient area, an area of farmer choice perhaps the width of the spring N applicator 100 feet or so long, with the full rate of recommended N plus 50 pounds N per acre more or less so that even if there is N loss due to spring rains there is enough N remaining to produce a crop supported by the soil/environment. The reading from this area are inserted into the algorithm to produce a yield prediction for N-nonlimiting corn growth. Readings from the rest of the field are compared to this value and if the field readings produce yield predictions lower than 95% of the non-limiting area yield, then a calculation of yield difference, the N content within the yield difference, divided by an efficiency factor (0.6 by default) of the N to be applied is made, producing the side-dress N rate. Details of the calculation are provided in the corn N algorithm circular indicated previously.

Spring wheat algorithms

The spring wheat algorithms for estimating top-dress N rates up to early tillering stage can be found at https://www.ndsu.edu/fileadmin/snrs/Files/sf1176-6.pdf .
The spring wheat algorithms for predicting agronomically practical immediate post-anthesis N application for protein enhancement can be found at
https://www.ndsu.edu/fileadmin/snrs/Files/sf1176-7__1_.pdf .
Implementation of the flag leaf sensor timing algorithm for protein enhancement requires knowledge of the inherent protein concentration characteristic of the cultivar. North Dakota State University published an annual report of yield and protein trials of many cultivars at all of the NDSU Research & Extension Centers in the state around the first of the year. High and low protein cultivars can be identified using the trial data.

Cover Crops

Cover crop biomass was much greater following winter wheat and spring wheat compared with cover crop interseeded into corn or soybean (Table 1). The greatest cover crop dry matter was less than 120 lb/acre, while seeding cover crop after short-season crop yielded dry matter from 695 to 5385 lb/acre.

Table 1. Dry matter yield of cover crop seeded following winter wheat or spring wheat, or interseeded into corn or soybean, Rutland and Gardner, 2016-2020.

	Crop before/during cover crop seeding			
	Winter wheat	Spring wheat	Corn	Soybean
Site Year	Pounds dry matter per acre			
Rutland 2016	3840	NA	40	NA
Rutland 2017	NA	4820	7	5
Gardner 2017	NA	22	NA	NA
Rutland 2018	NA	4500	13	48
Gardner 2018	NA	97	37	18
Rutland 2019	NA	5385	0	0
Gardner 2019	NA	18	117	101
Gardner 2020*	NA	695	65	0

*Rutland sites were abandoned after 2019 due to uncontrollable circumstances.

The growing seasons for 2017 through 2020 were relatively dry (Table 2). Despite interseeded cover crop at Gardner and Rutland, corn yield was not diminished by their growth (Table 3).

Table 2. Seasonal rainfall (May 1 through September 30) from nearest NDAWN weather station to site and departure from normal.

Site	Rainfall, in	Departure from normal, mm
Gardner 2017	14.1	-2.1
Rutland 2017	15.6	-0.1
Gardner 2018	13.7	-2.6
Rutland 2018	16.2	+0.6
Gardner 2020	14.6	-1.6

Table 3. Interseeded cover crop biomass and subsequent corn yields with interseeded cover crops 2017-2020. Differences between no cover crop and cover crop treatments were not significant (P<0.05) at any site.

Site Year	Interseed date	Covercrop Sampling date	CoverCrop Dry matter, lb/a	Yield No CoverCrop bu/a	Yield w/Cover Crop, bu/a
Gardner 2017	6/27	8/18	136	159	149
Rutland 2017	6/22	8/17	131	171	171
Gardner 2018	6/22	10/26	425	189	190
Rutland 2018	6/14	10/26	131	202	210
Gardner 2020	6/29	10/14	193	123	123

Leaf wetness sensors were installed at the Gardner location in 2019-2020 in cover crop and no-cover crop main plots at the 200 lb N/acre treatments in the corn studies. The mean number of days with dew, excluding days with rainfall were 40.5 with period of dew greater than 6 hours per event. In 2021, a small area (2 feet by 2 feet) was established with oat seeding in the Gardner corn study, in the 200 lb N per acre treatment (no cover crop was seeded in 2021). The oats emerged, and at 6 AM , August 30, the site was visited, and paper towel was used to blot the oat treatment for 30 seconds using a rubber-gloved hand. The mean weight of water from the blot was 0.5 g. The same technique was used to blot the crop residue with no growing cover crop in between the adjacent row, and 0 g water was collected on each replication. Although multiplying the water collected from the 30 second blot would amount to less than 0.2 inches of moisture during the period of interseeded cover crop growth, the blot does not consider the rest of the greater than 6 hours of dew collection experienced. The dew collected on the cover crop may be a reason for the lack of yield drag from cover crop interseeding.

The mean N concentration in cover collected in these studies was about 2%, with a C/N ratio of about 18. This would indicate some N release to the subsequent crop. However, N release was not seen in these studies. At Rutland for example (Figure 1), the cover crop following wheat contained about 100 lb N/acre, however, the N study in corn on this experiment indicated it required an N rate of about 100 lb/acre in the cover crop treatment to equal the 0 N rate in the no-cover crop treatment.

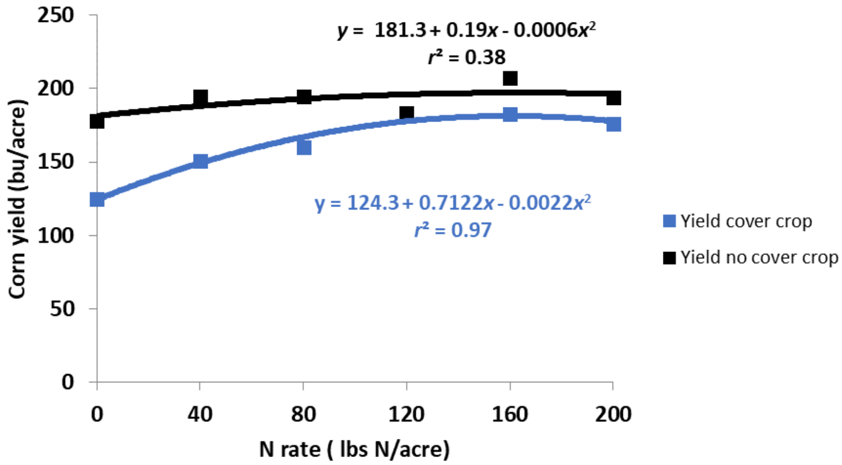

Figure 1. Corn yield response to N treatments, Rutland, 2018. Cover crop contained about 100 lb N/acre, which is about the rate of N necessary for cover crop yield to equal the yield of no cover crop at the 0 N rate.

To date, the N from the cover crop was not seen in the residual N soil tests at season end at any site. However, at some locations, the non-exchangeable ammonium content of the soil was greater with cover crop history than without (Table 4).

Table 4. Non-exchangeable ammonium, ppm at two sites in cover crop study.

	Non-exchangeable ammonium, ppm	
Site Year	**Cover Crop**	**No cover Crop**
Rutland 2018	60	41 sig P < 0.10
Gardner 2018	341	323 NS

Summary

Algorithms for use with active-optical sensors have been developed in North Dakota for use in corn and spring wheat. Cover crop establishment and total dry matter produced is much greater in the region after a short-season crop, such as winter wheat or spring wheat. The N taken up in the cover crop after short-season crop or interseeded into corn or soybean should not be subtracted from the N recommendation for the subsequent crop. Due to the dry seasons of these studies, it is unlikely that the N was ‘lost’ due to leaching or denitrification. It is possible that the ammonium is being held by the smectitic clays as non-exchangeable, although it has not been definitively established that this is its fate.

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