In-Season Nitrogen Applications: Predicting Needs and Verifying Responses for Yield and Protein

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Research Questions

Nitrogen is required for both yield and protein in spring wheat. Nitrogen is mobile and is subject to loss. In-season applications can often be more efficient than applying all fertilizer at planting, as it places more nitrogen closer to the point where the crop needs it the most. However, in-season applications are relatively more expensive than applying all N at planting, and occasionally in-season N can be "stranded" if rainfall does not occur soon after application. Knowing when an in-season application would be profitable and the type of response that can be expected from different application timings is needed for any advantages of a split application to be realized. We have two years of research on the effects of various side and topdress application timings on the yield and protein of spring wheat. In-addition, we have concurrently investigated possible methods for determining the need of in-season nitrogen. This has included the use of the Greenseeker™ and the RapidScan™ sensors. During the project we have addressed the following research questions: What is the impact of in-season applications on yield and protein at three different timings and the relative cost effectiveness of these applications? Why is the relationship between NDVI values and protein inconsistent? What are some of the environmental factors that affect this relationship? Lastly, can we use drones that measure NDVI in fields with reference nitrogen rich strips to predict the protein content of a field?

Results

Protein content was highest with the in-season application of N delayed until the boot stage (compared to at planting or the four-leaf stage). This treatment increased protein more than even the post-anthesis application, although there were only significant differences between the boot and post-anthesis applications at one location. The correlation between NDVI, yield and grain protein was inconsistent. The highest correlation was obtained from data collected at the Ada, MN location. Furthermore, these relationships were highest for data collected at the boot stage. This means that NDVI values are most useful later in the season, when options for applying additional N are limited. We have not yet fully analyzed the data collected using drones in farmers' fields. A multi-step process is needed to analyze these data and it has taken time to learn the various steps and implement them efficiently.

Application and Use

These data suggest the value of an in-season application of N for improving protein content. Boot stage applications have greater impact on protein than earlier applications. The cost effectiveness of these applications have not fully been analyzed, but it appears that they may be economical only when yields *and* the protein premium are expected to be high. Our preliminary data suggest that collecting NDVI with drones, coupled with nitrogen rich strips applied prior to planting could be an excellent way for farmers to detect the need for additional N. This system may give better guidance to farmers (and be easier to incorporate into their operation) than fertilizer applicators with mounted sensors, as has been used in other areas of the country. The results from this project can help improve the profitability of wheat producers by providing them with information to help them better understand when applying in-season nitrogen is likely to give a positive response.

Materials and Methods

Research was established at two locations in northwestern MN and two locations in eastern ND. Treatments consisted of two base levels of nitrogen augmented with N at the four-leaf, boot, and post-anthesis stages, using both UAN and urea. Values derived from the Greenseeker™ and RapidScan™ sensors were used to determine NDVI and or NDRE. Correlations between these values and yield and grain protein content were run to determine these relationships. We collaborated with the on-farm research group in Minnesota to conduct the UAV part of the project on seven fields across northwest Minnesota. Several of these growers applied a nitrogen-rich strip in selected wheat fields. These strips consisted of approximately 75 pounds per acre of nitrogen above the normal amount applied at planting and were at least 300 feet in length with the width of a fertilizer applicator pass. A UAV was flown at least once over each of the seven fields with several fields having multiple flyovers at different stages in the growing season. Care was taken that each fly-over would include the N-rich strip and adjacent untreated areas. Data from the sensors on the drone were stitched together to create a base map that is being used for further analysis. Data on protein were obtained from harvested strips and subsamples (the N-rich strip and an adjacent area of the same dimensions).

Economic Benefit to a Typical 500 Acre Wheat Enterprise

We are still trying to determine the predictability of NDVI and NDRE on protein to determine if these values can be used to inform the decision to apply N late in the growing season. This technique has promise in informing growers

when they are most likely to benefit from a post-anthesis application of N. If realized it has the potential of increasing revenue by up to $25,000 in a 500 acre wheat enterprise.

Related Research

We have some ongoing research funded from other sources that is looking at ways of increasing the efficiency and consistency of increasing grain protein with a foliar application of UAN.

Recommended Future Research

Expanded work with measuring NDVI with a drone and a nitrogen rich strip as a reference for applying additional nitrogen fertilizer.

Appendix

		Ada	Casselton 1st Planting	Casselton 2nd Planting	Red Lake Falls
GPC Mean (%)		13.0	13.9	15.4	13.2
GPC Range (%)		5.1	3.0	1.5	4.5
Yield Mean (bu/ac)		84.1	81.5	58.6	89.3
Yield Range (bu/ac)		40.9	22.5	20.7	53.1
TGP Mean (lb/ac)		658	682	538	743
TGP Range (lb/ac)		285	305	193	467
4-5 Leaf	NDVI vs GPC (R^2)	.06	NA	.05	.01
	NDVI vs TGP (R^2)	.32	NA	.08	.03
Flag Leaf	NDVI vs GPC (R^2)	.35	.00	NA	.25
	NDVI vs TGP (R^2)	.54	.00	NA	.29
Boot	NDVI vs GPC (R^2)	.46	.23	.35	.44
	NDVI vs TGP (R^2)	.65	.37	.41	.51

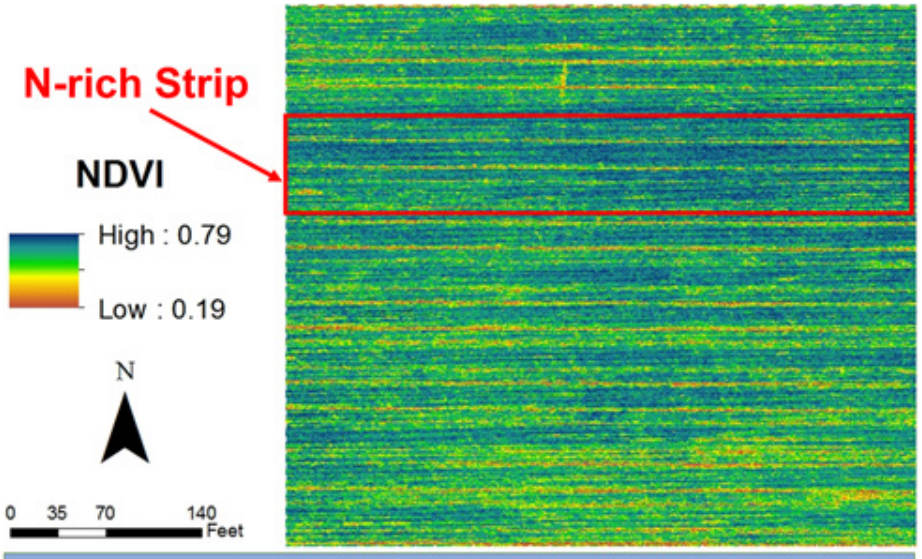

Fig. 3 – NDVI of a Producer Field Near Ada, MN

Publications

Ransom, J.K., M. Rellaford and N. Schmick. 2017. Can sensors and crop models predict the need for late-season nitrogen for protein enhancement in spring wheat? Abstracts, International Tri-Conference for Precision Agriculture in 2017. Hamilton, New Zealand.

Rellaford, M. and J.K. Ransom. 2017. Predicting the grain protein content of spring wheat with hand-held active sensors. Abstract and poster, 15th Annual Nitrogen Use Efficiency Conference. Baton Rouge, LA. (This poster won first place in the Marvin Stone Memorial Graduate Students Poster Competition.