Identifying Causes of Within-Field Protein Variability in Spring Wheat Using Precision Field Mapping and Aerial Imagery

Joel Ransom, Dept. of Plant Sciences, NDSU

Research Questions

Spring wheat profitability is influenced by grain protein content premiums or discounts when sold at the elevator. Wheat protein content can vary greatly across a field, and is influenced by many environmental factors, most importantly N and water availability. Protein maps created using combine-mounted protein analyzers can guide efforts to identify the underlying causes of protein variability within a field. Understanding these relationships could improve protein management practices, such as using a pre-plant or in-season variable rate N application to allocate fertilizer where it is most likely to increase grain protein content and profitability.

The objectives of this research are i) identify the most influential factors affecting within-field protein variability, ii) develop a model to predict protein content during the growing season using the identified influential factors and in-season UAV and satellite vegetation indices, and iii) identify a cost-effective approach to site-specific N management that maximizes both wheat yield and protein content to increase the overall profitability of wheat in MN, while also reducing fertilizer inputs and environmental loss.

Results

Wheat yield and protein maps, and UAV imagery were collected during the 2018 season. Protein appears to be inversely related to yield, and also appears to vary along with yield according to soil type within the field. Spatial analysis of the data will take place as we continue on into the 2019 and 2020 growing seasons.

Application and Use

Identifying the underlying factors affecting the spatial variability of protein within a field may help guide decisions related to managing protein content. In the future, we hope this research will result in a reliable, sensor-based model to predict protein content that could be used to prescribe variable rate in-season N applications. However, it will likely be many years before enough data are collected to produce a testable protein prediction model that could be used to test sensor-based N management recommendations.

Materials and Methods

Two CropScan 3000H protein analyzers manufactured by Next Instruments are currently in operation near Roseau and Thief River Falls, MN. The CropScan analyzes and records protein data every 7-11 seconds to create a georeferenced map of wheat protein while harvesting. A preliminary analysis assessing the relationships between protein and soil texture, OM, N, EC, weather, and imagery collected during the 2018 growing season will be used to more efficiently direct data collection efforts in the 2019-2020 growing seasons.

As we move forward, protein data will continue to be mapped on each of the cooperating producer's wheat fields, however intensive data collection will be limited to 2-4 fields to minimize cost and keep the volume of data to be analyzed at a manageable level. Nitrogen-rich and N-deficient strips will be established in these fields to aid yield and protein prediction using in-season NDVI/NDRE imagery obtained via satellite and a Matrice M-100 UAV equipped with a MicaSense RedEdge-M sensor. Fields will be flown with the UAV at the 4-5 leaf, boot, flag-leaf, and flowering stages. Satellite images nearest to these timings will be used for analysis. After harvest, fields will be zone soil sampled for texture, OM, and N. If found appropriate from the preliminary analysis in 2018, EC will be measured with a Veris cart (Veris Technologies) on fields that do not already have EC data. However, we would also like to test the use detailed digital soil maps as a more cost-effective alternative to EC mapping. ArcGIS and R mapping and statistical software will be used to spatially analyze the relationships between these data to identify which factors are the most influential on protein content within a field, and if these factors can be used to predict protein content during the growing season.

Economic Benefit to a Typical 500 Acre Wheat Enterprise

Potential economic benefits are unknown at this time, but will hopefully become more clear as we explore and analyze the data moving forward.

Related Research

Mapping protein variability in a field has been researched previously in Montana and Washington to map the variability of spring wheat protein within fields using hand-

sampling approaches. Exploratory research using automated protein mapping of winter wheat has recently begun in Missouri as well.

In a related project funded by NDSU, NDVI values are being collected with drone-mounted sensors from fields of wheat and corn that have a nitrogen rich strip in order to determine if these data can be used in developing prescription fertilizer maps. Though there will be limited data collected on protein in this project, some of the procedures used may apply to the MN-funded project to monitor N sufficiency.

This research is also being conducted in partnership with the Minnesota Wheat Research & Promotion Council's On-Farm Research Network.

Recommended Future Research

A more thorough analysis of existing data is needed before we can recommend additional research. Defining the following zones within the fields included this year may provide insight into how N fertilization zones should be set up: 1- high yield and high protein; 2- High yield and low protein; 3- Low yield and high protein; 4- Low yield and low protein.

Appendix

Yield and Protein in Pennington County