IWC Annual Report

Grant Code: AP6317

Title: Active Canopy Sensors to Prescribe In-Season Supplemental Nitrogen for Wheat

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Abstract:

The University of Idaho's wheat production guides were last updated in the early 2000s requiring new research evaluating wheat responses to nitrogen. Further, given the high cost of nitrogen fertilizers, improving nitrogen use efficiency is an important aspect of a farm remaining economically viable. Split fertilizer applications may improve fertilizer use efficiency and reduce the total N rate applied. This practice allows time for the wheat crop to integrate weather, mineralization, residual N, and pest pressure into its growth before a producer makes a final N fertility decision. Crop sensing technologies can then be used to rapidly assess the crop's greenness accounting for field variability and providing variable N rate prescriptions. The objective of this study was to evaluate the response of irrigated spring hard red, hard white, and soft white wheat yield, grain protein, and nitrogen use efficiency to increasing nitrogen fertilizer rates applied at planting or split applied as a small amount at planting and the remainder applied at tillering. An additional objective was to determine if in-season soil, plant tissue, and crop canopy sensing measurements could be used to predict yield and nitrogen demand.

Our initial results indicated that the approximate optimal pre-plant nitrogen rate to maximize yield was 250 lb nitrogen/acre for HWSW and HRSW at both Aberdeen and Kimberly while it was 200 or more lb/acre for SWSW. When nitrogen was split-applied, the yield was often reduced relative to a single application, especially at higher nitrogen fertilizer rates. This may indicate that the yield potential is reduced if supplemental nitrogen is applied at mid- to late tillering. There does not appear to be a difference in yield for SWSW when nitrogen fertilizer is applied at planting or as a 2-way split or a 3-way split.

Background/Objectives:

It is estimated that <51% of fertilizer nitrogen applied is used by cereal crops with the rest either being lost to the environment or bound in soil organic matter. For wheat production, nitrogen must be carefully managed to prevent excessive vegetative growth and lodging, delayed maturity, pest pressure, and to ensure grain protein meets end-use targets. The University of Idaho's current N fertilizer rate recommendations is determined by accounting for the amount of residual soil inorganic N in the soil, the previous crop, soil mineralization potential, and yield goal. These guidelines were last updated in the early 2000s. One of the objectives of this study is to provide more recent data about the response of wheat yield and grain protein content to nitrogen availability. Further, given the high cost of nitrogen fertilizers, improving nitrogen use efficiency is an important aspect of a farm remaining economically viable. Split fertilizer applications are one approach that may improve fertilizer use efficiency, reduce the total N rate applied, and improve a producer's overall sustainability. Split-applying nitrogen fertilizer allows time for the wheat crop to integrate weather, mineralization, residual N, and pest pressure into its growth before a producer makes a final N fertility decision. Crop sensing technologies can then be used to rapidly assess the crop's greenness accounting for field variability and providing variable N rate prescriptions.

The objectives of this study were:

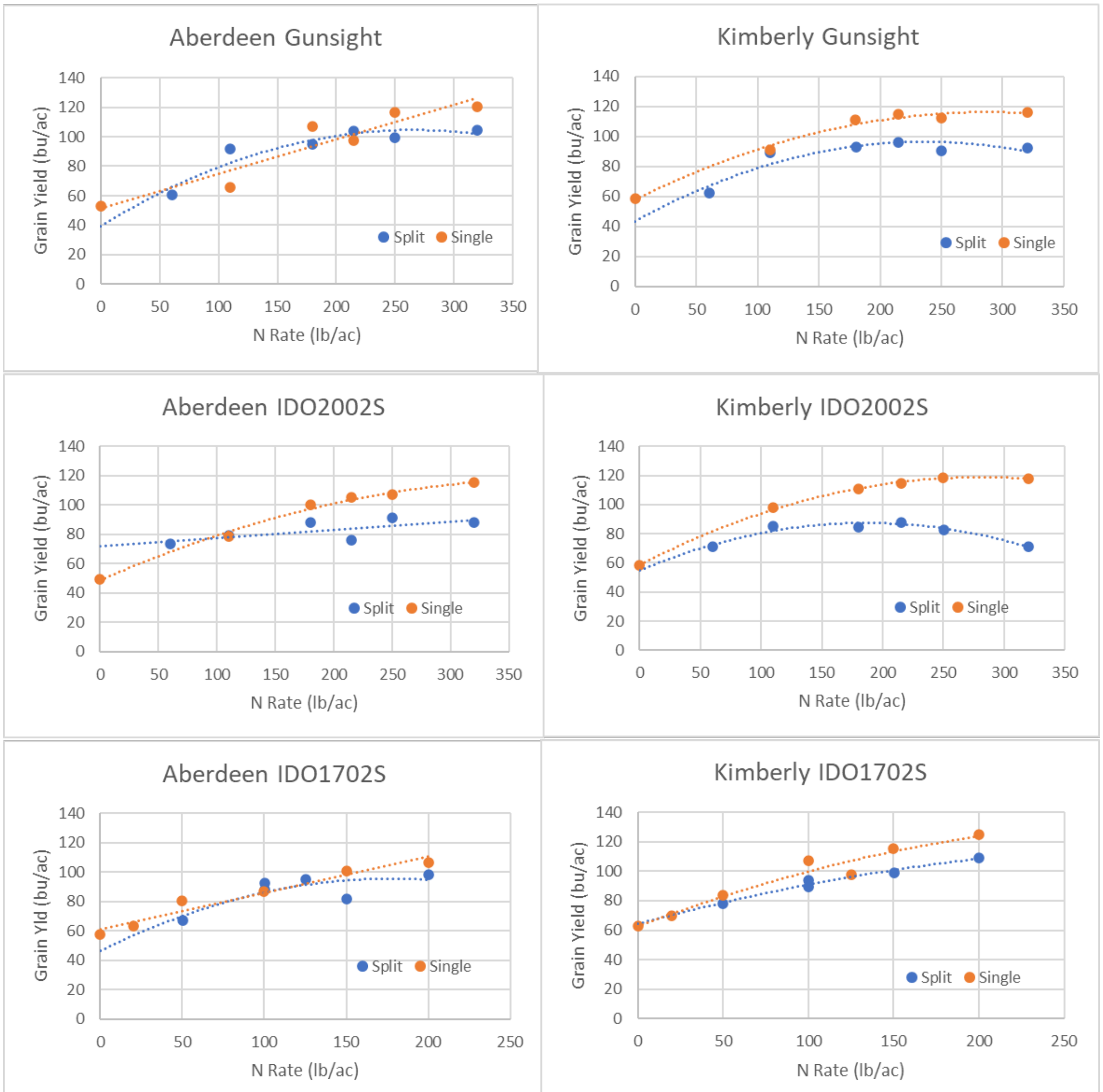
1) Determine hard red, hard white, and soft white wheat yield, grain protein, and N use efficiency response to in-season N application
2) Develop crop sensor algorithms for Idaho conditions for different wheat classes

Results / Accomplishments:

We successfully established field plots at the Aberdeen and Kimberly Research and Extension Centers in coordination with the USDA NIFA AFRI Sustainable Agriculture Systems grant (2021-2025). For the USDA NIFA grant, we banded urea at planting below and to the side of the seed row at 0, 70, 140, 175, and 210 lb N ac^{-1} for Gunsight (HRSW) and IDO2002S (HWSW) and topdressed with 40 lb N ac^{-1} at heading. For IDO1702S (SWSW) we applied 0, 50, 100, 150, 200 lb N ac^{-1} at planting. For the IWC grant, we applied an additional treatment of 280 lb N ac^{-1} at planting and topdressed with 40 lb N ac^{-1} at heading for Gunsight and IDO2002S. Split applications were band applied as 20 lb N ac^{-1} as urea at planting and 0, 50, 120, 155, 190, or 260 lb N ac^{-1} was applied at tillering and topdressed with 40 lb N ac^{-1} at heading for Gunsight and IDO2002S. For IDO1702S, the additional treatments were 20 lb N ac^{-1} as urea banded between the seed rows at planting and 0, 30, 80, 105, 130, or 180 lb N ac^{-1} topdressed as urea at tillering. An additional treatment was 20 lb N ac^{-1} at planting, 60 lb N ac^{-1} at tillering, and 20 lb N ac^{-1} at heading.

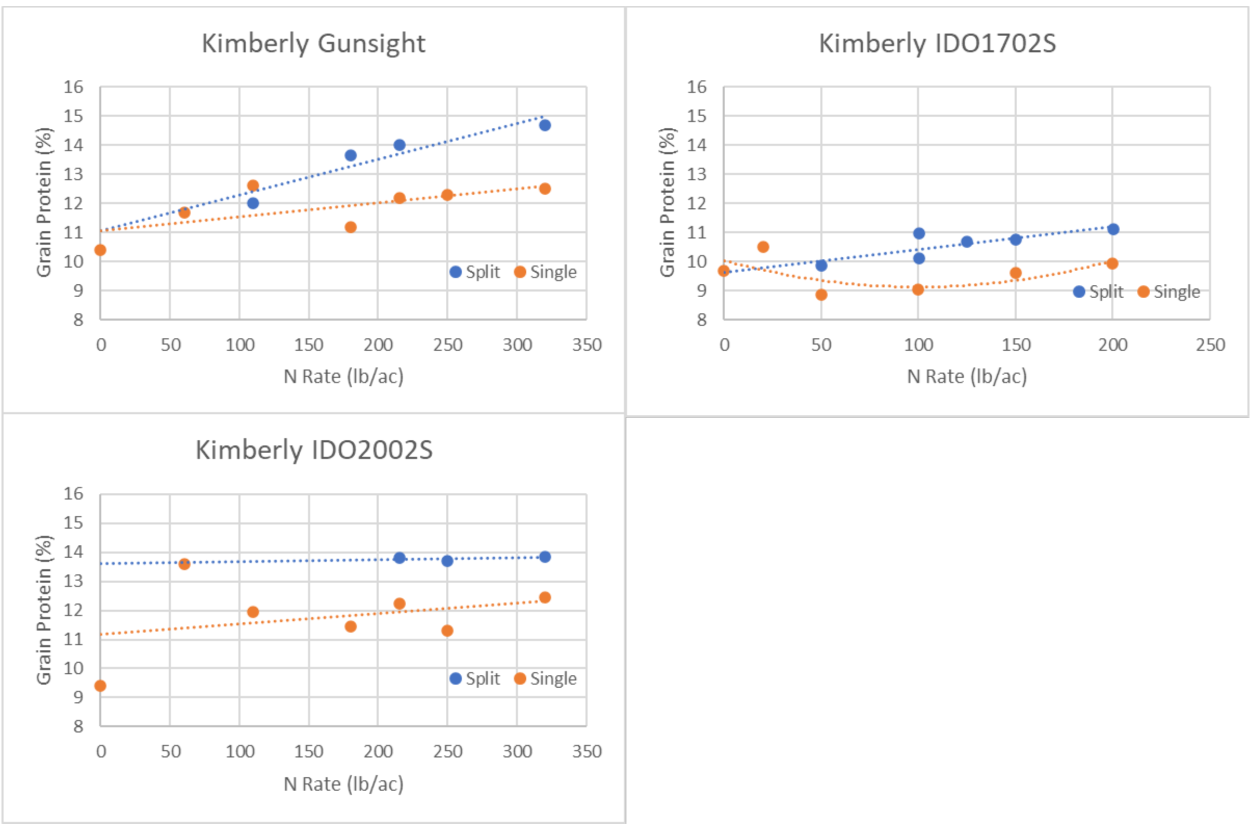
We collected soil samples by replication at 1-foot increments down to 2 feet at pre-plant and analyzed them for complete nutrient analysis. Additional soil samples were collected from each plot at 1-foot increments down to 2 feet at jointing, flowering, and post-harvest for a total of 960 soil samples. These soil samples were dried, ground to pass through a 2 mm sieve, and have been submitted to Brookside for analysis for soil nitrate and ammonium content. We also took bulk density samples from the 0-1' and 1-2' depths. Unless bulk density has been measured, a common rule of thumb is to multiply the measured concentration of nutrients by 3.6 (assuming a bulk density of ~1.3 g cm^{-3}). We found that the soils' bulk density values were 1.45 and 1.52 g cm^{-3} at the 0-1' and 1-2' depths at Kimberly and 1.69 and 1.78 g cm^{-3} at Aberdeen. Our pre-plant soil sample indicated that we had 3 and 3 ppm nitrate-N at the 0-1' and 1-2' depth in Aberdeen. Using the multiplication factor of 3.6, the residual preplant nitrate-N is estimated at 22 lb nitrate-N ac^{-1}. However, using the real bulk density values, the residual preplant nitrate-N content was 28 lb nitrate-N ac^{-1}. At lower soil test values, the difference between the two values is small, but with higher residual soil N (such as when wheat follows potatoes) the difference increases. This implies that it is important that growers understand their soils' physical properties to correctly estimate soil nutrient availability for wheat production. This message was shared at the 2022 Southern Idaho Cereal School on February 2.

Crop canopy greenness was measured from each plot using the Apogee, SPAD, and Greenseeker sensors at jointing and flowering (960 measurements). Sensor measurements will be transcribed from paper to electronic format by a post-doc recently hired to help analyze the results from this project. Whole plant tissue samples were collected from each plot at jointing, flowering, and immediately before harvest by harvesting 1 meter of row. Samples collected before harvest were partitioned into heads and straw. The heads were counted and will be threshed to quantify the number of viable heads per meter of row and the average number of kernels per head. All plant tissue samples were dried, weighed, and submitted to Brookside Laboratories for total N analysis. We have nearly completed the analysis of the grain samples for test weight and protein concentration.



Our initial results indicated that all three wheat varieties' yield responded positively to pre-plant and split nitrogen applications at both Aberdeen and Kimberly. A linear response was observed for a single application at planting for Gunsight at Aberdeen and IDO1702S at both Aberdeen and Kimberly. Linear responses were also observed for a split application at Aberdeen

IDO2002S and Kimberly IDO1702S. Linear responses indicate yield was not optimized for our range of nitrogen rates and that yield would have continued to increase with additional nitrogen inputs. The quadratic response observed at all other locations and varieties indicate that sufficient nitrogen was applied to optimize yield at the nitrogen rate where the regression line either plateaus or begins to decline. The approximate optimal pre-plant nitrogen rate was 250 lb nitrogen/acre for Gunsight and IDO2002S at both Aberdeen and Kimberly while it was 200 or more lb/acre for IDO1702S. When nitrogen was split-applied, the yield was often reduced relative to a single application, especially at higher nitrogen fertilizer rates and when the study was performed in Kimberly. This may indicate that the yield potential is reduced if supplemental nitrogen is applied at mid- to late tillering. Another potential explanation could be that Kimberly warms faster than Aberdeen. This accelerates the rate of physiological development allowing less time for the developing crop to utilize split fertilizer nitrogen for vegetative production and later grain production. It is of interest to note that for IDO1702S, there does not appear to be a difference in yield when nitrogen fertilizer is applied as a 2-way split or a 3-way split.



Grain protein concentration was often greater with a split application than when nitrogen was applied at planting. When nitrogen is taken up as wheat is transitioning from vegetative to reproductive development, a greater portion of the nitrogen is translocated to the grain resulting in higher grain protein concentration. At Kimberly, for the split application treatments, grain protein increased from 12.0 to 14.7% and 9.9 to 11.1% for Gunsight and IDO1702S, respectively.

Outreach / Applications / Adoption:

The data from this study was presented at the 2022 University of Idaho Winter Cereal School and as a poster at the 2022 American Society of Agronomy-Crop Science Society of America-Soil Science Society of America annual conference held in Baltimore, Maryland in November 2022. Data from FY2022 was also presented at 2 field days in Aberdeen and 1 field day in Kimberly during our summer cereal tours. At the time of the tour, nitrogen treatment differences were evident. We received excellent participation and questions from growers and industry representatives about nitrogen management strategies.

Next Steps / Projections

Dr. Spackman recently hired a postdoc to compile and analyze the data from this study. We will use data collected from FY22, FY23, and the next year of research to investigate the relationship of in-season soil and plant tissue nitrogen content to wheat yield and quality and nitrogen use efficiency. We will calculate the soil-crop nitrogen balance. We will also correlate our crop sensor readings to grain yield. We will create algorithms to estimate the in-season N rate required to achieve targeted yield and protein goals. We will also compare the apparent N use efficiency of the single vs split applications.

Publications / Presentations / Popular Articles / News Releases / Variety Releases:

Spackman, J.A. 2022. Nitrogen Management: Increasing Fertilizer Efficacy. Valley Ag Agronomists Meeting. Jackpot, NV. 18 Nov. 2022. (60 minutes)

Spackman, J.A., J. Bevan, O.S. Walsh, A. Adjesiwor, O. Adeyemi, J. Sagers, and R. Findlay. 2022. Nitrogen Fertilizer Rate and Timing Implication for Hard Red, Hard White, and Soft White Wheat Production in Southern Idaho. ASA-CSSA-SSSA Annual Meetings. Baltimore, MD. 6 – 9 Nov. 2022.

Walsh, O., **J.A. Spackman,** and A.T. Adjesiwor. Agronomy Reports. ISAID Annual Meeting 2022 and Regenerative Ag Workshop. Twin Falls, ID. 3 Oct. 2022.

Spackman, J.A. 2022. Nitrogen Management Research in Small Grains. University of Idaho - Limagrain Cereal Seeds Field Day. 19 July, 2022. (100 attendees, 20 minutes).

Spackman, J.A. and J. Bevan. 2022. Nitrogen Management for Cereal Production. Pesticide and Nutrient Management Field Day. Aberdeen, ID. 28 June, 2022. (55 attendees, 20 minutes)

Spackman, J.A. 2022. Nitrogen Management for Cereal Production. Snake River Weed Management and Tour Field Day. Kimberly, ID. 22 June, 2022. (55 attendees, 15 minutes).

Spackman, J.A. 2022. Nitrogen and Sulfur Fertility Research Updates for Barley and Wheat. Southern Idaho Cereal School. Aberdeen, ID. 2 Feb. 2022. (141 attendees, 30 minutes).