ANNUAL REPORT

Grant Code: AP5460
Title: Active Canopy Sensors to Prescribe In-Season Supplemental Nitrogen for Wheat
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Accomplishments

The objectives of this study were:
Objective 1: Determine hard red, hard white, and soft white wheat yield and grain protein response to in-season N application
Objective 2: Assess if split-applications can be done to achieve yield and protein goals for different wheat classes
Objective 3: Develop crop sensor algorithms for Idaho conditions for different wheat classes

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 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 1,736 soil samples. These soil samples were dried, ground to pass through a 2 mm sieve, and are currently in storage awaiting sample analysis for soil nitrate 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 (assumes a bulk density of ~1.3 g cm^{-3}). We found that the soils’ bulk density values were 1.4 and 1.56 g cm^{-3} at the 0-1' and 1-2’ depths at Kimberly and 1.69 and 1.71 g cm^{-3} at Aberdeen. Our pre-plant soil sample indicated that we had 19 and 12 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 112 lb nitrate-N ac^{-1}. However, using the real bulk density values, the residual preplant nitrate-N content was 158 lb nitrate-N ac^{-1}. This implies that it is extremely important that growers understand their soils’ physical properties to correctly estimate soil nutrient availability for wheat production. This message will be 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 (1,728 measurements). Sensor measurements are currently being transcribed from paper to electronic format by two graduate students recently hired to help with 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 number of 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 and are currently being ground by my newly hired technician, Jacob Bevan, in preparation for total N analysis (1,152 samples). We have also recently finished analyzing the grain samples for test weight and protein concentration.

Table 1: The nitrogen rate required to maximize wheat grain yield as a single or a split application. The reported nitrogen rate is residual soil nitrogen at the time of planting (0-2') plus the applied fertilizer rate. Residual soil N (0-2') was 158 lb N ac^{-1} at Aberdeen and 57 lb N ac^{-1} at Kimberly. For the split application, the nitrogen rate was applied as a series of splits and indicated as planting/tillering/heading.

	Gunsight		IDO2002S		IDO1702S	
Aberdeen	Single Application	Split Application	Single Application	Split Application	Single Application	Split Application
N rate (lb N ac^{-1})	222/0/40	178/50/40	348/0/40	178/50/40	290/0	178/30
Yield (bu ac^{-1})	122	124	139	125	134	131
Protein (%)	12.8	13.9	14.0	14.0	11.0	11.7
Kimberly						
N rate (lb N ac^{-1})	231/0/40	77/50/40	337/0/40	77/50/40	257/0	77/30
Yield (bu ac^{-1})	90	48	89	42	99	48
Protein (%)	13.4	13.9	14.0	14.5	12.3	12.0

Our initial results indicated that all three wheat varieties' yield responded positively to nitrogen applications at both Aberdeen and Kimberly. When comparing the single application at planting, similar total amounts of nitrogen were required to maximize yield at both Aberdeen and Kimberly within a variety, but the actual yield was greater at Aberdeen. This is likely partially due to the hotter conditions in Kimberly than Aberdeen that accelerated grain development and maturity.

At both Aberdeen and Kimberly, there was no difference in yield between the 20/50/40 lb N ac^{-1} treatment (Gunsight and IDO2002S) and any of the other three-way splits (plant/tiller/heading) or the 20/30 two way split and any of the other two way splits (plant/tiller) for IDO1702S. Yields were similar between the single and the split application within variety at Aberdeen. In contrast, grain yield was reduced by nearly 50% with the split application compared to the single application at Kimberly. This may be because the split-applications were applied at early jointing after yield potential had already been set.

At Aberdeen, grain protein for the single application treatments increased with increasing nitrogen rate from 14.2 to 14.9% for Gunsight, 14.1 to 15.0% for IDO2002S, and 12.3 to 12.9% for IDO1702S. For the split application treatments, grain protein increased from 14.3 to 15.0%, 14.5 to 15.0%, and 12.0 to 12.9% for Gunsight, IDO2002S, and IDO1702S, respectively.

At Kimberly, grain protein for the single application treatments increased with increasing nitrogen rate from 12.7 to 14.1% for Gunsight, 12.8 to 14.5% for IDO2002S, and 10.7 to 11.7% for IDO1702S. For the split application treatments, grain protein increased from 17.3 to 18.7%, 17.1 to 17.9%, and 13.9 to 16.1% for Gunsight, IDO2002S, and IDO1702S, respectively. The high protein concentration values for the split applications across all varieties are likely the combined effect of nitrogen fertilization at late tillering and heat stress.

Projections: 1) We have identified two new sites for 2022 that have low (<50 lb N ac^{-1}) residual soil N. We will use the current data plus the next two years of research to investigate the relationship of in-season soil and plant tissue to calculate the soil-crop N balance and how they relate to crop sensor readings. 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:
This data will be presented at the 2022 Winter Cereal School and the 2022 American Society of Agronomy-Crop Science Society of America-Soil Science Society of America annual conference.