ANNUAL REPORT

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

The objectives of this study were:
Objective 1: Determine food, feed, and malt barley 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 barley classes
Objective 3: Develop crop sensor algorithms for Idaho conditions for different barley 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, 45, 90, 135, and 180 lb N ac^{-1} for Altorado (feed) and ABI Voyager (malt) and 0, 30, 60, 90, 120 lb N ac^{-1} for Goldenhart (food). For the IBC grant, we applied 20 lb N as urea ac^{-1} at planting and 0, 25, 50, 70, 115, or 160 lb N ac^{-1} at tillering for Altorado and ABI Voyager. An additional treatment was applied as 20 lb N ac^{-1} at planting, 50 lb N ac^{-1} at tillering, and 20 lb N ac^{-1} at heading. For Goldenhart, we applied treatments of 150 lb N ac^{-1} at planting; 20 lb N at planting top-dressed with 0, 40, 70, 100, or 130 lb N ac^{-1}; and 20 lb N ac^{-1} at planting, 20 lb N ac^{-1} at tillering, and 20 lb N ac^{-1} at heading.

Soil samples were collected by replication at 1 foot increments down to 2 feet at pre-plant and analyzed 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 nutrient 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} at Aberdeen. 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 barley production.

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 the graduate student 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 in preparation for total N analysis (1,152 samples). Additional measurements collected from each study were yield, plumps and thins, test weight, and grain protein content.

When we initially selected the site at Aberdeen, we knew that our residual soil N was near the upper limit of barley yield response to N rate. However, we thought that we would still see a N response followed by a plateau in yield. In contrast, we found that there was no difference in yield between fertilizer applications done all at planting (PlantN), top-dressed at jointing (JointN), or top-dressed at jointing and heading (HeadN). Because of the high residual pre-plant soil N content at Aberdeen, we did not observe treatment differences for yield for Altorado, Goldenhart, or ABI Voyager (Table 1). Surprisingly, we also did not observe differences in protein concentration except for the PlantN treatments for Altorado where protein concentration increased with increasing N rate. At Kimberly, grain yield generally increased with increasing N rate for all varieties. When N was split applied, there was either no difference in yield or a reduction relative to a single application at planting. Protein concentration was typically within malting specifications when applied at planting but was too high when split applied.

Table 1. Grain yield and protein concentration for N fertilizer rates applied at planting (PlantN), split as part at planting and the remainder at jointing (JointN) or with a third split at heading (HeadN). Within each location, variety, and N application timing, means followed by the same lowercase letter are not statistically different at $P>0.05$. Within location and variety, means with the same uppercase letter are not statistically different at $P>0.05$.

			Aberdeen		Kimberly	
		N Rate (lb/ac)	Grain Yield (Bu/ac)	Protein (%)	Grain Yield (Bu/ac)	Protein (%)
Altorado	PlantN	0	172a	11b	47b	11.7a
		45	170a	10.7b	80b	10.6ab
		90	174aA	11.5a A	119aA	10.1bB
		135	170a	11.5a	120a	11.5ab
		180	176a	11.8a	130a	11.9a
		Pr>F	0.861	0.003	<0.001	0.008
	JointN	20/0	169a	10.8a	62b	11.3c
		20/25	177a	11.0a	68ab	12.1bc
		20/50	172a	10.9a	81ab	13.9ab
		20/70	172aA	11.4aA	81abB	13bA
		20/115	172a	11.8a	94ab	14.7a
		20/160	162a	12.1a	101a	14.9a
		Pr>F	0.669	0.202	0.015	<0.001

	HeadN	20/70/20	176A	11.3A	81B	14.2A
		Pr>F	0.943	0.707	0.004	<0.001
Goldenhart	PlantN	0	97a	14.3a	24bc	17.9a
		30	116a	14.6a	40b	14.7ab
		60	109aA	15.6aA	56abA	13.5bC
		90	115a	16.6a	59ab	14.9ab
		120	110a	15.9a	67ab	14.7ab
		150	112a	15.6a	83a	15.3a
		Pr>F	0.367	0.203	<0.001	0.02
	JointN	20/0	104a	14.9a	35c	15.5c
		20/40	103aA	14.6aA	46bcA	18.2bB
		20/70	109a	15.6a	51abc	19.9ab
		20/100	107a	16.1a	59ab	20.1ab
		20/130	111a	16.3a	65a	20.5a
		Pr>F	0.887	0.556	0.001	<0.001
	HeadN	20/20/20	109A	15.5A	42A	19.9A
		Pr>F	0.83	0.725	0.176	<0.001
ABI Voyager	PlantN	0	152a	10.4a	37b	11.9a
		45	162a	11.1a	59b	9.8bc
		90	169aA	11.2aA	103aA	10.4bB
		135	161a	11.7a	118a	11.4ab
		180	167a	11.8a	124a	12.3a
		Pr>F	0.352	0.118	<0.001	<0.001
	JointN	20/0	172a	10.6b	50b	10.7c
		20/25	156a	10.7b	65ab	11.7bc
		20/50	165a	11.5ab	76ab	12.6b
		20/70	153aA	10.7bA	80aB	14.1abA
		20/115	153a	11.8ab	87a	15.3a
		20/160	149a	12.4a	89a	15.2a
		Pr>F	0.329	0.009	0.003	<0.001
	HeadN	20/70/20	154A	11.3A	78B	14.5A
		Pr>F	0.052	0.493	0.016	<0.001

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.