# ANNUAL REPORT

**Grant Code:** AP5158
**Title**: Barley Yield and Protein Response to Nitrogen and Sulfur Rates and Application Timing
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## Accomplishments

The objectives of this study were:
1) Assess the effect of variety and the rate of nitrogen (N) and sulfur (S) application on plant nutrient utilization, grain yield and protein, and soil responses for three barley varieties
2) Identify the critical concentration ranges of N and S for developing correlated tissue test guidelines for malt, feed, and food barley under Idaho growing conditions
3) Develop a correlation-calibration response curve to establish the relationship between plant tissue N and S content with active canopy sensors for Idaho growing conditions

We successfully established field plots at the Aberdeen and Kimberly Research and Extension Centers during the 2021 growing season. We formed a collaborative relationship with Paul Stukenholtz who agreed to perform the soil, tissue, and water sample analyses associated with this project (value of $215,000). We also received an additional grant for $4,950 from the American Malting Barley Association to run select samples for malt quality at Montana State University's malt quality testing lab.

We hired Jacob Bevan as a research technician in July 2021. He had recently completed his MS at the University of Idaho in Jianli Chen's wheat breeding program. Because of his research background and experience with wheat, he was able to rapidly adjust to barley research and hit the ground running. He is an essential member of the Barley Agronomy research program and is doing an excellent job of keeping the project samples organized and processed in a timely manner.

We hired two undergraduate interns (one from the University of Idaho, one from Brigham Young University – Idaho) to help with this project during the summer of 2021. They were able to use this project to gain research experience and share their experience with their peers.

We had originally extended a Ph.D. assistantship to a student last spring, but due to Covid-19 and familial constraints, she was unable to join the program. In her place, Olanrewaju Adeyemi was hired in January 2022 as a MS graduate assistant.

To meet our objectives, we applied eight N fertilizer treatments (0, 40, 80, 120, 160 lb N $ac^{-1}$ as urea at planting; 40/20, 40/40, or 40/80 lb N $ac^{-1}$ split applied as urea at planting/jointing) by three S fertilizer treatments (0, 15, 30 lb S $ac^{-1}$ as potassium sulfate applied at planting). All 24 of these treatments were applied to Claymore (feed), Julie (food), and M179 (malt) barley for a total of 72 treatments and 576 plots.

Soil samples were collected by replication at 1 foot increments down to 3 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 3,460 soil samples. These soil samples were immediately submitted to Stukenholtz Labs and analyzed for a complete nutrient analysis from the top foot and nitrate and sulfate content in the second foot. We also took bulk density samples from the 0-1' and 1-2' depths.

Crop canopy greenness was measured from each plot using the Apogee, SPAD, and Greenseeker sensors at jointing and flowering (3,456 measurements). Sensor measurements are currently being transcribed from paper to an electronic format by Olanrewaju. 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 have been or soon will be submitted to Stukenholtz Labs for a complete nutrient analysis (2,304 samples). Additional measurements collected from each study were yield, plumps and thins, test weight, and grain protein content.

A water sample was collected at each irrigation event and analyzed for nutrient content including nitrate-N and sulfate-S. Averaged over the growing season, Aberdeen irrigation water supplied 70 lb sulfate-S and 15 lb nitrate-N per acre foot of water while Kimberly supplied 46 lb sulfate-S and 4 lb nitrate-N per acre foot of water. At the time of study initiation, we expected that Kimberly would have some sulfate-S because the irrigation water is derived from the Snake River. In contrast, we expected Aberdeen to have low sulfate-S and nitrate-N content because the irrigation water source was a well. Upon further investigation at the end of the growing season, we found that the well was only 60' deep and is likely recharged from the Springfield canal system. The water samples collected at both sites indicates that growers may improve their nutrient management and save on input costs by periodically testing their irrigation water.

When we initially selected the study location sites at Aberdeen and Kimberly, we expected the top three feet of the soil profile to have 144 lb N $ac^{-1}$ and 85 lb S $ac^{-1}$ in the top 3 feet of the soil profile at Aberdeen and 54 lb N $ac^{-1}$ and 90 lb S $ac^{-1}$ at Kimberly. We knew that our residual soil N was near the upper limit of barley yield response to N rate at Aberdeen. However, we hypothesized that we would still see a N response followed by a plateau in yield. Likewise, we also expected to see a nitrogen by sulfur interaction because soil sulfate-S was <6 ppm in the top 2 feet of the profile. In contrast, we found that there was not a significant interaction of nitrogen by sulfur rate or application timing on grain yield. However, we did observe that protein content increased with increasing N rate for both the treatments applied at planting and at jointing at both Aberdeen and Kimberly. At Aberdeen, protein concentration was consistently within malting specifications irrespective of the N rate or timing whereas in Kimberly, the split application treatments' protein concentration were too high. The difference in protein concentration at the two locations may be due to heat stress at Kimberly. While it was disappointing that we did not observe a significant effect of S on yield or grain protein concentration, we expect to see differences in soluble:insoluble protein. We will soon be sending our grain samples to Moscow where Zonglie Hong will conduct this analysis.

**Projections:** 1) We have identified two new potential sites for the 2022 growing season that have low (<50 lb N $ac^{-1}$) residual soil N. We will use the current data plus the next one or possibly two years of research to investigate the relationship of in-season soil and plant tissue nutrient content to calculate the soil-crop nutrient balance. Because we are analyzing each soil and plant tissue sample for complete nutrient analysis, we will be able to quantify the value of the grain and straw. With today's fertilizer prices, there may be greater value in returning the straw and its associated nutrients back to the field rather than exporting the straw and replenishing the lost nutrients through fertilizer. Future research might investigate the bio-availability of nutrients released from decomposing straw for the following crop. We might also investigate how straw removal/retention impacts soil physical and chemical properties including soil organic matter content, bulk density, and water holding capacity.
Future work with the current data will develop algorithms for predicting N sufficiency for targeted yield and quality goals. These algorithms will be developed for soil samples, plant tissue samples, and crop canopy sensor readings.

**Publications:**
Spackman, J.A. Z. Hong, and J. Marshall. 2021. Barley Response to Nitrogen and Sulfur Fertilization. ASA-CSSA-SSSA Annual Meetings. Salt Lake City, UT. 7-10 Nov. 2021.

Some of 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.