ANNUAL REPORT

Grant Code: AP6591
Title: Barley Yield and Protein Response to Nitrogen and Sulfur Rates and Application Timing
Personnel: Drs. Jared Spackman, Zonglie Hong, and Juliet Marshall
Collaborators: Paul Stukenholtz, Jacob Bevan, Albert Adjesiwor, Joseph Sagers, Reed Findlay
Address: Dr. Jared Spackman, University of Idaho (UI) Aberdeen Research & Extension Center, Aberdeen, ID 83210; 208-312-2454; jspackman@uidaho.edu

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 Research and Extension Center and Brigham Young University–Idaho (BYUI) in Rexburg, Idaho during the 2022 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 of $5,000 from the American Malting Barley Association to run select samples for malt quality at the USDA malt quality testing lab.

Jacob Bevan has continued as the program's research technician. Because of his research background and experience with Dr. Jianli Chen's wheat breeding program, 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 promptly.

We hired 2 undergraduate students from BYUI, 1 intern from Idaho State University, and 6 high school students to help with this and other barley and wheat projects during the summer of 2022. These individuals were able to use this project to gain research experience and a greater appreciation for small grain production. Two graduate students also worked on this project. Olanrewaju Adeyemi will use this project for his MS thesis and has done an excellent job of learning about the project and presenting results at several conferences. To help my graduate students gain a greater understanding of the inputs (e.g., fertilizer, seed, and water) and uses of barley, I taught a 1 credit Small Grains Production Tour. My graduate students and 5 others from Dr. Jianli Chen's wheat breeding program and Dr. Nora Olsen's potato program toured Simplot's fertilizer plant in Pocatello, Anheuser Busch's malting facility, Grain Craft's milling facility, Scoular's protein processing plant, and several dams/waterfalls (American Falls, Milner, Shoshone Falls).

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 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 was 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.

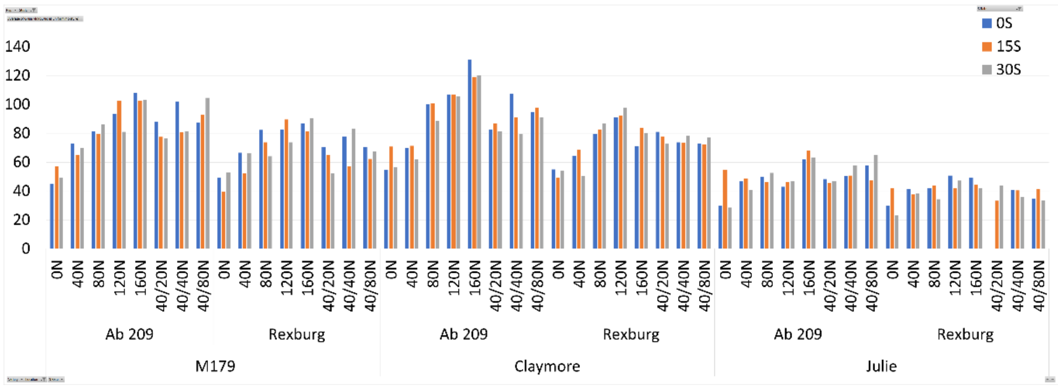

Figure 1 2022 grain yield (bu/ac at 13.5% moisture) for M179 (malt), Claymore (feed), and Julie (food) barley grown in Aberdeen (Ab 209) and Rexburg.

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 46 lb sulfate-S and 3 lb nitrate-N per acre-foot of water while Rexburg supplied 33 lb sulfate-S and 7 lb nitrate-N per acre-foot of water. At the time of study initiation, we expected that the Aberdeen and Rexburg sites would have minimal sulfate-S because the irrigation water is derived from a well. Upon further investigation at the end of the growing season, we found that the Aberdeen well was only 100’ deep and is likely recharged from the Springfield canal system. The Rexburg well is much deeper but went dry about 2 irrigation events before we intended to terminate irrigation. The water samples collected at both sites indicate that growers may improve their nutrient management and save on input costs by periodically testing their irrigation water.

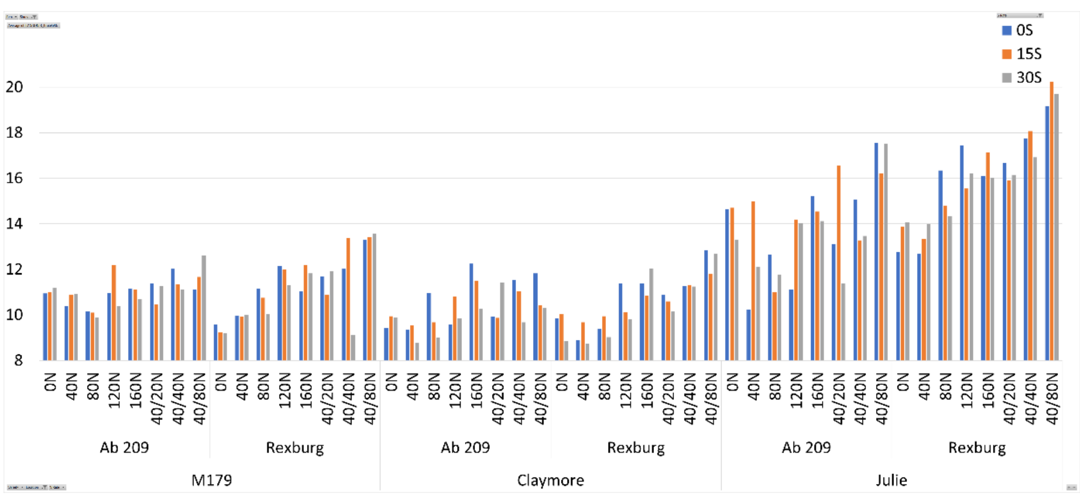

Figure 2 2022 grain protein concentration (%) for M179 (malt), Claymore (feed), and Julie (food) barley grown in Aberdeen (Ab 209) and Rexburg.

As in 2021, we did not see a significant response of grain yield or protein concentration to S rate. This is likely due to adequate sulfate-S content in the irrigation water. For equivalent treatments, Rexburg produced lower yields than Aberdeen, likely due to the well going dry during the grain fill. At both Aberdeen and Rexburg, grain yield increased linearly with increasing N rate for all varieties in Aberdeen and M179 at Rexburg. A linear response indicates that N fertility was insufficient to maximize yield. At Rexburg, Claymore and Julie had quadratic responses with a maximum yield occurring at approximately 120 lb N/ac. Split applications tended to produce similar yields to a single application done at planting.

Grain protein concentration remained within malting parameters for M179 for most N rates except the lowest N rates and the 40/80 split at Rexburg. For Julie, grain protein increased with increasing N rate and was greatest when N was split applied. 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 and in grain metabolites (analysis to be conducted by Sarah Whitcomb from the USDA malt quality lab).

Projections: Olanrewaju is working to compile and analyze the data from this study. We will use data collected from FY22 and FY23 to investigate the relationship of in-season soil and plant tissue nitrogen content to barley yield and quality and nitrogen use efficiency. 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 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.

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:

1. Spackman, J.A. and Rogers, C. 2022. Nitrogen and Sulfur Fertilizer Management and Managing Water for Barley Production. Tri-State Grain Growers Convention. Coeur d'Alene, ID. 1 Dec. 2022. (18 attendees, 60 minutes)
2. Spackman, J.A. 2022. Nitrogen Management: Increasing Fertilizer Efficacy. Valley Ag Agronomists Meeting. Jackpot, NV. 18 Nov. 2022. (60 minutes)
3. Adeyemi, O., J.A. Spackman, J. Sagers, Z. Hong, J. Marshall, J. Bevan, and R. Findlay. 2022. Barley Yield and Protein Response to Nitrogen and Sulfur Rates and Application Timing. ASA-CSSA-SSSA Annual Meetings. Baltimore, MD. 6 – 9 Nov. 2022.
4. Spackman, J.A. Irrigated Spring Barley Yield, Grain Quality, and Malt Quality Response to Nitrogen and Sulfur Fertilization. (Oral Presentation and Abstract). 23rd North American Barley Researchers Workshop and 43rd Barley Improvement Conference. Sacramento, CA. 22–24 Sep. 2022.
5. 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).
6. 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)
7. 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).