

Grant Code: New**Title:** Wheat Yield, Quality, and Bake Response to Nitrogen and Sulfur Fertilization**Personnel:** Jared Spackman, Assistant Professor; Sarah Windes, UI Wheat Quality Lab Manager; Grant Loomis, Blaine County; Justin Hatch, Caribou and Bear Lake County;**Address:** Jared Spackman 1693 S. 2700 W. Aberdeen, ID 83210; (208) 312-2454;jspackman@uidaho.edu

Justification/Rationale: Nitrogen (N) and sulfur (S) are critical nutrients for producing high-quality wheat but can be difficult to manage in semi-arid production systems where rainfall and, periodically, irrigation are variable. High spring precipitation or excessive irrigation events can favor N and S leaching reducing yield and grain quality. However, N fertilizer additives such as urease inhibitors, nitrification inhibitors, and controlled-release products may improve N availability. Recent research by Dr. Spackman found that irrigated spring wheat and barley are highly responsive to nitrogen fertilizer but barley does not respond to S fertilizer when irrigated with water derived from the Snake River because of its high sulfate-S content. However, many small grain producers within the Snake River plain annually apply elemental S as a way to reduce soil pH. Growers outside of the Snake River plain have reported yield responses to S additions. Further, they requested that additional research be conducted to compare S fertilizer sources and rates. S fertilizer is sold in several forms including elemental S prills, micronized elemental S, elemental S blended with other fertilizers such as urea or phosphate, and combinations of sulfate salts (ammonium sulfate, potassium sulfate, and calcium sulfate). While many different forms of S are sold as fertilizers, only the sulfate form is plant available. Elemental sulfur products must be oxidized by bacteria into the sulfate form before they are available to the crop.

Objectives:

- 1) Assess the effect of S fertilizer rates and sources on hard red and soft white spring wheat grown outside the Snake River plain in terms of grain yield, quality, and end-use quality.
- 2) Evaluate N fertilizer stabilizer/protection products for wheat yield and grain quality.

Methods/Plan of Work:

Table 1 Fertilizer treatments. GS; Grower standard; N, nitrogen; P2O5, phosphorus; K2O, potassium; S, sulfur; AMS, ammonium sulfate; TSP, triple super phosphate; MAP-MST, monoammonium phosphate with micronized elemental sulfur; SRx Thrive, micronized elemental sulfur embedded in urea; SRx Sulfur 85, 85% elemental S in bentonite clay prills; K2SO4, potassium sulfate; SuperU, urea impregnated with a urease and nitrification inhibitor; Agrotain, a urease inhibitor; ESN, Environmentally Smart Nitrogen- a controlled release N fertilizer;

Treatment	N lb/ac	P2O5 lb/ac	K2O lb/ac	S lb/ac
Unfertilized Check	0	0	0	0
S Check	GS	54	0	0
AMS/Urea/TSP	GS	54	0	2.5
AMS/Urea/TSP	GS	54	0	5

AMS/Urea/TSP	GS	54	0	10	Field experiments will be conducted at two locations outside the Snake River plain in Eastern Idaho (e.g., Soda Springs, Bellevue, Ririe, Ashton, or Teton). A hard red and a soft white spring wheat will be planted and receive the fertilizer treatments described in Table 1. In most treatments, N and phosphorus fertilizer rates will be balanced using urea or triple superphosphate. Treatments will be replicated 4 times and plots will be 5' by 30'. All other nutrients will be managed to be non-limiting according to current UI nutrient management guidelines for malt barley. A pre-plant soil sample will be collected at one-foot
AMS/Urea/TSP	GS	54	0	20	
AMS/Urea/TSP	GS	54	0	40	
Gypsum/Urea/TSP	GS	54	0	10	
Gypsum/Urea/TSP	GS	54	0	20	
MAP-MST/Urea/TSP	GS	54	0	10	
MAP-MST/Urea/TSP	GS	54	0	20	
SRx Thrive/Urea/TSP	GS	54	0	10	
SRx Thrive/Urea/TSP	GS	54	0	20	
SRx Sulfur 85/ Urea/TSP	GS	54	0	10	
SRx Sulfur 85/ Urea/TSP	GS	54	0	20	
K ₂ SO ₄	GS	54	24	10	
K ₂ SO ₄	GS	54	47	20	
AMS/SuperU/TSP	GS	54	0	10	
AMS/Urea+Agrotain/TSP	GS	54	0	10	
AMS/Urea/50%ESN/TSP	GS	54	0	10	
AMS/Urea/TSP	GS+20%	54	0	10	
AMS/Urea/TSP	GS-20%	54	0	10	

increments to two-foot depths and analyzed for complete nutrient analysis.

The field will be planted using a no-till drill and all fertilizer treatments will be banded midway between the seed rows. Each plot will be evaluated for emergence, canopy cover, and greenness at late tillering using the Canopeo phone app and a Greenseeker. Immediately before harvest, plant height, tiller number, and kernels per head will be measured. At maturity, yield and yield components (test weight, grain protein concentration) will be measured in each plot. A subsample of grain will be analyzed for flour and bread (hard red) or cookie (soft white) bake quality at the wheat quality lab at Aberdeen.

The response of dependent variables (i.e., yield, grain protein, etc.) to N and S applications will be assessed using ANOVA and regression analysis when appropriate. An economic analysis will be done to see which of the N and S fertilizer products provide the best return on investment.

The Idaho Barley Commission is currently funding a similar study in malt barley and we have requested funding from the Fluid Fertilizer Foundation to investigate the efficacy of liquid fertilizer treatments including ammonium thiosulfate, potassium thiosulfate, calcium thiosulfate, and urea ammonium nitrate at multiple rates.

Duration: This will be the first of 2 years

Cooperation/Complementation: Dr. Spackman is responsible for managing the field sites and collecting the field data, agronomic data analysis, and manuscript preparation. Ms. Windes will run the flour and bake quality analyses. County Extension educators will assist with establishing the research plots, data collection, and disseminating project results.

Anticipated Benefits, Expected Outcomes and Impacts, and Transfer of Information: The data generated from this study will be used to build a database of wheat responses to N and S

fertilization under irrigated (Bellevue) and dryland (Soda Springs) conditions. This data, in coordination with other researchers' projects, will be used to update the UI's spring wheat production guide. We anticipate that this project will generate at least 1 peer-reviewed journal article on the agronomic response of wheat to N and S fertilization. The results from this trial will be shared at professional meetings (such as the Tri-Societies meetings, Western Nutrient Management Conference), Extension events (Cereal School, field days), and Extension publications. The raw dataset will be published in a publicly available data repository to ensure the longevity of the dataset and its availability for future research applications.

Literature Review: N and S have a synergistic effect on improving wheat plant development, yield, and grain quality where N availability determines tiller number, seed number, and grain fill. S availability improves N use efficiency, improves stress tolerance, and reduces susceptibility to pests and diseases¹⁻⁵. When N and/or S are deficient, chlorophyll production is inhibited resulting in spindly, pale-yellow plants^{1,2}. Further, both N and S are critical components of grain metabolites including grain proteins. S fertilizer has been shown to improve bread wheat gluten index, grain protein, S-containing amino-acid concentrations, dough stability, and loaf volume.⁶ Current UI guidelines suggest that a good rule of thumb is to apply 1 lb sulfate-S for every 10 lb N applied⁷. Elemental S sources (e.g., TigerSol 90) require that the prill is broken down and oxidized by soil microbes releasing only 33% of the S to the crop each year.⁸ In contrast, micronized elemental S sources are typically bonded to other N or phosphorus fertilizers (e.g., SRX Thrive or MAP-MST) that readily dissolve. The oxidation rate of micronized elemental S is much faster due to the smaller particle size.⁹ Sulfate-S sources (e.g., ammonium sulfate) are readily plant-available but may be susceptible to leaching if precipitation or irrigation is excessive.

References:

1. Barczak, B., and E. Majcherczak. 2008. *J. Cent. Eur. Agric.* 9(4): 777–784.
2. Dari, B., C.W. Rogers, and X. Liang. 2019. *J. Plant Nutr.* 42(9): 1061–1071. doi: 10.1080/01904167.2019.1589504.
3. Prystupa, P., A. Peton, E. Pagano, and F.H.G. Gutierrez-Boem. 2019. *J. Cereal Sci.* 85(December 2018): 228–235. doi: 10.1016/j.jcs.2018.12.014.
4. Salvagiotti, F., J.M. Castellarín, D.J. Miralles, and H.M. Pedrol. 2009. *F. Crop. Res.* 113(2): 170–177. doi: 10.1016/j.fcr.2009.05.003.
5. Fuentes-Lara, L.O. et al., 2019. *Molecules*. 24(12): 2282. <https://doi.org/10.3390/molecules24122282>
6. Jarvan et al. 2008. *Agronomy Research* 6(2): 459-469.
7. Roberston, Guy, and Brown. 2003. *Southern Idaho Dryland Winter Wheat Production Guide*.
8. Havlin et al., 2005. *Soil Fertility and Fertilizers*. 7th Edition.
9. <https://smartnutritionmst.com/products/mst-phosphate/>

**FY2025
COMMODITY COMMISSION BUDGET
Principal Investigator: (Jared Spackman)**

Allocated by _____ (Commission/Organization)	during FY2023	\$	-
Allocated by _____ (Commission/Organization)	during FY2024	\$	-

REQUESTED SUPPORT:		<u>Awarded for FY2024</u>	<u>Requested for FY2025</u>
Budget Categories			
(10) Salary (staff, post-docs, et NOTE: Faculty salary/fringe NOT allowed)		\$ -	\$ 4,637
(12) Temporary Help/IH		\$ -	\$ 4,779
(11) Fringe Benefits		\$ -	\$ 2,312
(20) Travel		\$ -	\$ 4,985
(30) Other Expenses		\$ -	\$ 17,408
(40) Capital Outlay >\$5k		\$ -	\$ -
(45) Capital Outlay <\$5k		\$ -	\$ -
(70) Graduate Student Tuition/Fees		\$ -	\$ -
TOTALS		\$ -	\$ 34,121

TOTAL BUDGET REQUESTED FOR FY2025:	\$ 34,121
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BREAKDOWN FOR MULTIPLE INDEXES:					
Budget Categories	Spackman	(Insert Co-PI Name)	(Insert Co-PI Name)	(Insert Co-PI Name)	
(10) Salary (staff, post-docs, et	\$ 4,637	\$ -	\$ -	\$ -	\$ -
(12) Temporary Help	\$ 4,779	\$ -	\$ -	\$ -	\$ -
(11) Fringe Benefits	\$ 2,312	\$ -	\$ -	\$ -	\$ -
(20) Travel	\$ 4,985	\$ -	\$ -	\$ -	\$ -
(30) Other Expenses	\$ 17,408	\$ -	\$ -	\$ -	\$ -
(40) Capital Outlay >\$5k	\$ -	\$ -	\$ -	\$ -	\$ -
(45) Capital Outlay <\$5k	\$ -	\$ -	\$ -	\$ -	\$ -
(70) Graduate Student Tuition/Fees	\$ -	\$ -	\$ -	\$ -	\$ -
TOTALS	\$ 34,121	\$ -	\$ -	\$ -	\$ -
				Total Sub-budgets	\$ 34,121