FOR ADMINISTRATIVE USE
Program Area Code Proposal Code

Minnesota Wheat Research and Promotion Council

RESEARCH PROPOSAL GRANT APPLICATION

1. NAME AND ADDRESS OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

Name: North Dakota State University Carrington Research Extension Center
Address: NDSU Dept. 4000, PO Box 6050, Fargo, ND 58108-6050

2. TITLE OF PROPOSAL

Enhancing Spring Wheat Yields through Split In-Season Nitrogen and Sulfur Applications in Conventional and No-Till Systems

3. PRINCIPAL INVESTIGATOR(S)	**4. PI #1 BUSINESS ADDRESS**
Sergio Cabello-Leiva	663 Hwy 281 N, Carrington, ND 58421
PI# 2 Name: Mike Ostlie	
PI# 3 Name: Szilvia Yuja	

5. PROPOSED PROJECT DATES (calendar years)	**6. TOTAL PROJECT COST**	**7. PI #1 PHONE NO.**
2024 season Note: Research Reports are Due November 15th of Each Year	CREC, Carrington ND: $15,727 CLC, Staples, MN: $15,357 Total request: $31,084	**218-731-4296**

8. RESEARCH OBJECTIVES: (List objectives to be accomplished by research grant)

Hypothesis: the use of a split application of nitrogen and sulfur significantly increases wheat yield under conventional and no-till cropping systems

Objectives:

- Determine the combined effect of nitrogen and sulfur split rates, finding the correct ratio to achieve the highest wheat yield and quality in conventional and no-till systems
- Determine the simple (separate) effect, in wheat yield and quality, of nitrogen and sulfur split application in conventional and no-till systems
- Determine the best method to predict nitrogen and sulfur plant status and fertilizer rates, considering regular soil testing, plant analysis, and multispectral data from active and passive sensors. If the multispectral data is significant, we will proceed to use the most accurate vegetation index to predict and correct in-season N and S fertilizer rates in wheat

Attach a 2-page detailed discussion of importance of the proposal to wheat profitability; how study complements previous research in area; procedures to be used; and competency of the research group in achieving research objectives. (Please keep the proposal concise, only 2 pages will be provided reviewers).

Signature Of Principal Investigator	**Date**	**Phone Number**
	01/08/2024	**218-731-4296**

Signature Of Authorized Representative	**Title**	**Date**
Amy B. Scott Digitally signed by Amy B. Scott Date: 2024.01.11 16:29:21 -06'00'	**Assistant Director, Sponsored Programs Administration**	**01/08/2024**

Address Of Authorized Representative	**Phone Number**
PO Box 6050, Dept. 4000, Fargo, ND 58108-6050	**701-652-2951**

Minnesota Wheat Research and Promotion Council
RESEARCH PROPOSAL GRANT APPLICATION
(2-pages maximum)

Project Title: Enhancing Spring Wheat Yields through Split In-Season Nitrogen and Sulfur Applications in Conventional and No-Till Systems

Importance of this project to the profitability of wheat producers:

Accurate nitrogen (N) and sulfur (S) fertilizer management in wheat is one of the critical goals during the growing season. Both nutrients directly impact photosynthesis because they are a central part of the chlorophyll molecule (Andrews et al., 2013). Many farmers in North Dakota will apply excessive amounts of N to ensure a high yield (Tenorio et al., 2020). However, this is not an economical and environmentally suitable decision. Farmers use soil analysis to supply the correct N and S fertilizers rate. However, these results are not always accurate enough for several variables and interactions, such as temperature, rainfall (timing and amount), soil physical, biological, and chemical properties, plant genetics, and timing and placement of fertilizers. Active (Crop Circle) and passive (drone and multispectral camera) optical multispectral sensors will offer an inexpensive possibility to provide high temporal resolution for N and S plant status, allowing accurate mid-season N and S recommendations, achieving the best economical and optimal N and S rates for wheat and achieving high yield and high protein content.

Franzen et al. (2016) showed poor prediction of sulfur in soil analysis because of the complexity of changes during the season due to weather in North Dakota. Also, they determined that active optical sensors can be a valuable tool to predict in season, N and S deficiency. They have another exciting finding: this study found that high nitrogen rates can increase sulfur deficiency severity, which opens a new approach in the cropping system, presenting a more significant challenge under no-till. Ullah et al. (2022) found that the interaction of N and S applications significantly increases wheat yield, with one N and two S rates. They are demonstrating a positive interaction between nutrients and grain yield. These results suggest an update to N and S rate recommendations is needed in the states of Minnesota and North Dakota.

This research will help farmers determine the benefits of nitrogen and sulfur split application. Soil analyses early in the spring will not always reflect the N and S availability during the season because it is highly dependent on organic matter, mineralization, and weather conditions. Because of that, using multispectral data taken in season will allow us to determine the correct N and S rate in a split application, decreasing fertilizer leaching and increasing wheat yields and quality. This finding will easily apply to conventional and no-till wheat production in Minnesota and North Dakota.

Procedures:

Field establishment: **The first location will be Carrington, ND; plots will be located on dryland, no-till loamy soils. The second location will be Central Minnesota Demonstration and Research Irrigation Farm in Staples, MN; plots will be located on conventional tillage irrigated sandy soils.** N and S leaching risk increases significantly in both environments, affecting crop nutrient availability and groundwater. The experimental unit will be 25 ft x 12 ft in size.

Wheat will be randomized in a complete block design (RCBD) with a factorial arrangement with four replicates in late April (based on weather and soil conditions). The first factor will be five nitrogen rate treatments, including 0 (check), 50, 75, 100, and 150% of the recommended N rate. The second factor will include three sulfur rates: 0 (check), 100, and 150% of the recommended S rate. In addition, one treatment with 100% N and S rate will be applied without split application as a control. N and S rates will be split 60% as a starter and 40% as the Feekes 5 stage.
Nitrogen rates for Carrington will use the ND wheat N calculator, based on soil analyses. Nitrogen rates in Staples, MN, will be based on Nitrogen guidelines from the University of Minnesota, using the soil analysis as a baseline, too.

Plant Sampling: Mid-season biomass samples will be taken from a four sq ft section of the wheat plot at Feekes 5 stage. These samples will be weighed and tested for nitrogen (N) and sulfur (S) content. The sulfur-to-nitrogen ratio will indicate sulfur sufficiency in the plant tissue. Wheat biomass will be retaken close to harvest from a four sq ft section, and these samples will be weighed but not analyzed. Each plot will be harvested to determine grain yield, test weight, and protein content.

Soil sampling: Composite samples will be taken at 0-6- and 6-24-inches depth in early spring for NO3-N soil pH, P, K, Sulfate-S, Zinc, pH, and organic matter, and samples taken at 6-24 inches will be tested for NO3-N and Sulfate-S. These samples will be used to determine the N and S recommendations. In-season soil sampling will be done in wheat at Feekes 5 stage, testing for NO3-N and Sulfate-S. After harvest, samples will be collected at 0-24 inches depth, testing for NO3-N and Sulfate-S.

Multispectral wheat canopy data:
A Crop Circle ACS-430 (Holland Scientific Inc, Lincoln, NE, USA) optical active sensor will collect canopy reflectance at 670, 730, and 780 nm (red, red-edge, and near-infrared), and the Greenseeker hand held sensor will collect NDVI in each plot at Feekes stages 3, , 5, and 10.5 of the wheat stages. Once data are obtained, several vegetation spectral indexes (VIs) will be calculated using MATLAB 2023b.
A drone DJI Phantom 4 MicaSense Red-Edge multispectral camera will collect canopy reflectance images at 550, 670, 715, and 840 (green, red, red-edge, and near-infrared). Data collection will be at Feekes stages 3, 5, and 10.5 of the wheat stages. Once images are obtained, several vegetation spectral indexes (VIs) will be calculated using MATLAB 2023b.

Weather and soil data: Daily temperature (min and max), relative humidity, and rainfall will be obtained from the NDAWN weather station in North Dakota. Soil moisture and temperature will be obtained from check plots with a Decagon 5TM soil moisture sensor (5 ,15, and 30 cm depth), and reads will be recorded daily with a Decagon EM50 datalogger.

Statistical analysis will be conducted using standard procedures for a randomized complete block design (RCBD). For all variables above, analysis of variance with the MIXED procedure of SAS 9.4. A mean separation test will be performed using the least significant difference (LSD) ($P \leq 0.05$).

Regional linkages to other research activities: There are no linkages to other research activities to this proposal.

List any other secured, pending, or planned submissions to outside funding sources for this work. None

Research Group: Sergio Cabello-Leiva (Soil Scientist), Mike Ostlie (CREC Director and Agronomist), and Szilvia Yuja (Soil Research Specialist)

Relationship to past projects: Split in-season application of N and S in wheat, evaluated with active and passive multispectral sensors, is a new approach in ND and MN. We used research and results from Dr. Dave Franzen and Dr, Jasper Teboh to set our methodology to achieve our objectives.

Estimate the budget requirements: Partial salary support is requested for a research specialist and research technicians to plant, maintain and harvest the trials and for part time staff to collect optical sensor data and help with trial maintenance and data collection. Fringe benefits are calculated at 60% for research specialist, 66% for technical staff, and 10% for part time staff. Repairs are for repairs to the equipment used to complete the project including tractors, planters, and combines. Operating fees are for soil sample and plant analyses. Materials and supplies are for fuel, fertilizer, chemical, plot stakes and supplies, and laboratory supplies. Travel funds are for travel to and from the trial areas during the growing season and to acquire supplies. Travel to the Minnesota site includes mileage, hotel, and per diem for trips to collect soil samples, trips for sensor data collection, and harvest. Other direct costs are lab fees for soil sample analyses and plant analyses for both locations (composite soil sample 2 sample x $35/sample = $70; soil N and S 384 samples x $17.70/sample = $6,796; Biomass N and S 128 samples x $33.9/sample = $4,338) and a contracted services agreement ($1,400) to Central Minnesota Demonstration and Research Farm in Staples for the test site.

References:

Andrews, M., J.A. Raven, and P.J. Lea. 2013. Do plants need nitrate? The mechanisms by which nitrogen form affects plants: Do plants need nitrate? Annals of applied biology 163(2): 174–199. doi: 10.1111/aab.12045.

Franzen, D.W., L.K. Sharma, H. Bu, and A. Denton. 2016. Evidence for the ability of active-optical sensors to detect sulfur deficiency in corn. Agron J 108(5): 2158–2162. doi: 10.2134/agronj2016.05.0287.

Tenorio, F.A.M., E.L. McLellan, A.J. Eagle, K.G. Cassman, D. Andersen, et al. 2020. Benchmarking impact of nitrogen inputs on grain yield and environmental performance of producer fields in the western US Corn Belt. Agric Ecosyst Environ 294. doi: 10.1016/j.agee.2020.106865.

Ullah, I., D. Muhammad, and M. Mussarat. 2023. Effect of Various Nitrogen Sources at Various Sulfur Levels on Maize–Wheat Yield and N/S Uptake under Different Climatic Conditions. J Plant Growth Regul 42(3): 2073–2087. doi: 10.1007/s00344-022-10682-6.

Minnesota Wheat Research and Promotion Council

RESEARCH PROJECT PROPOSAL BUDGET

Project Title: Enhancing Spring Wheat Yields through Split In-Season Nitrogen and Sulfur Applications in Conventional and No-Till Systems

Principal Investigator(s) / Project Director(s) Sergio Cabello Leiva	Funds Requested For Year 1 (2024)	Year 2 (2025)	Year 3 (2026)
A. Salaries and Wages	$	$	$
1. Co-principal Investigator(s)			
2. Senior Associates			
3. Research Associates – Post Doctorate			
4. Other Professionals	500		
5. Graduate Students			
6. Prebaccalaureate Students	1,000		
7. Secretarial - Clerical			
8. Technical, Shop and Other	6,000		
B. Fringe Benefits	4,360		
C. Consulting and Professional Services			
D. Supplies and Services	1,570		
E. Travel	4,300		
F. Sub-Contracts			
G. Repairs & Maintenance	750		
H. Rentals & Lease			
I. Other Expenses (Direct Cost Attachment)	12,604		
TOTAL AMOUNT OF THIS REQUEST (per year)	**$ 31,084**	**$**	**$**

Carrington REC Budget for MN Wheat Council				
Enhancing Spring Wheat Yields through Split In-Season Nitrogen and Sulfur Applications in Conventional and No-Till Systems				
Budget	**Description**	**CREC, Carrington, ND**	**CLC, Staples, MN**	**Total**
Account Code			**(funds to CREC)**	**Project**
515000	Faculty/Scientist			
515000	Research Assistant			
517000	Graduate Student			
511000	Professional Support	500		500
511000	Technical Support	4,000	2,000	6,000
513000	Student Assistant			
513000	PT Support Staff/Hourly Worker	1,000		1,000
	Total salaries and wages	5,500	2,000	7,500
516000	Fringe Benefits	3,040	1,320	4,360
	Total Salaries, wages and fringe benefits	8,540	3,320	11,860
691000	Equipment purchases over $5,000			
552000	Equipment purchases under $5,000			
621000	Fees (advertising, freight, outside lab fees)	5,602	5,602	11,204
623000	Fees (consultant fees & expenses, contracted services)		1,400	
542000	Printing			
532000	Publications - journal articles			
582000	Rent or Lease payments (land or equipment)			
591000	Repairs	500	250	750
532000	Research & Instructional supplies (lab, books, etc.)			
535000	Research supplies (seed, feed, fertilizer, farm, veterinary, etc.)	785	785	1,570
624000	Subcontracts			1,400
521000	Domestic Travel	300	4,000	4,300
521000	Foreign Travel			
	Total Operating Costs	7,187	12,037	19,224
	Total Request ($)	**15,727**	**15,357**	**31,084**

Detail of Other Direct Costs, Outside lab fees for Locations in Minnesota and North Dakota		
Sample type	**Carrington, ND ($)**	**Staples. MN ($)**
composite soil start of trial 1 sample @ $35/sample	35	35
Soil nitrate and sulfate at Feekes 5 per plot, 2 depths 64 samples @ $17.7	2,265	2,265
post-harvest soil N and S per plot, 1 depth 64 samples @ $17.7	1,133	1,133
Wheat mid-season biomass N and S (complete analysis price) 64 samples @ $33.9	2,169	2,169
Total per location	**5,602**	**5,602**
Total both locations		**11,204**