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
Address: Office of Sponsored Programs Administration
Dept #4000 PO Box 6050, Fargo, ND 58108-6050

2. TITLE OF PROPOSAL
The economics, nitrogen use efficiency, and performance of wheat in response to sulfur and nitrogen fertilizer levels and their interaction

3. PRINCIPAL INVESTIGATOR(S)	**4. PI #1 BUSINESS ADDRESS**
Jasper M Teboh	NDSU Carrington Research Extension Center PO Box 219 663 Hwy. 281 NE Carrington, ND 58421
PI# 2 Name: Szilvia Zilahi-Sebess	
PI# 3 Name: Ezra Aberle	

5. PROPOSED PROJECT DATES (calendar years)	**6. TOTAL PROJECT COST**	**7. PI #1 PHONE NO.**
2015 Note: Research Reports are Due November 15th of Each Year	22,339	701-652-2951

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

1. Assess the impact of sulfur fertilizer on grain yield and protein, and profitability
2. To assess the interaction of nitrogen and sulfur rates on spring wheat performance

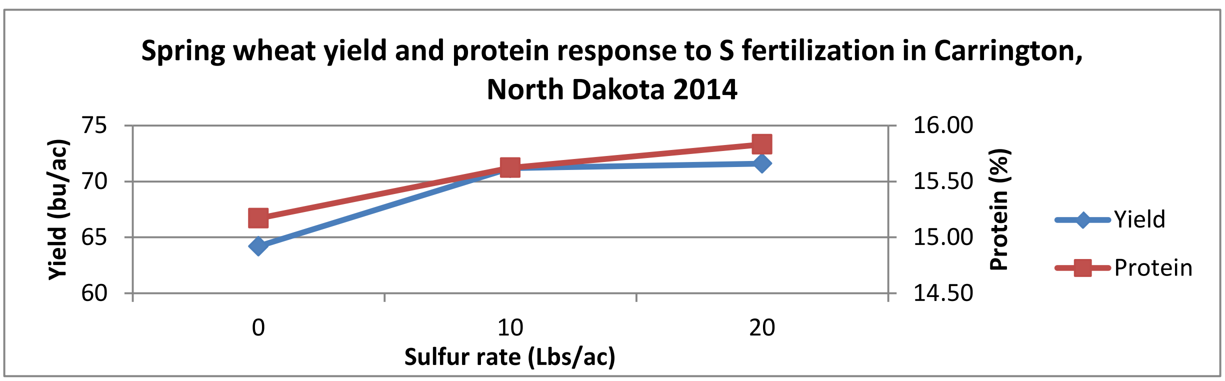
Attach a 2-page detailed discussion of importance of the proposal to wheat profitability; how study complements previous research in area; procedures to be used; and competency of the research group in achieving research objectives. (Please keep the proposal concise, only 2 pages will be provided reviewers).

Signature Of Principal Investigator	**Date**	**Phone Number**
[signature]	2/3/2015	701-652-2951
Signature Of Authorized Representative	**Title**	**Date**
Jill McKenzie	Award & Program Officer	2/3/15
Address Of Authorized Representative		**Phone Number**
North Dakota State University Office of Sponsored Programs Administration Dept #4000 PO Box 6050, Fargo, ND 58108-6050		701-231-8976

Project Title: The economics, nitrogen use efficiency, and wheat performance in response to sulfur and nitrogen fertilizer levels and their interaction

Importance of this project to the profitability of wheat producers: In recent years producers have been observing sulfur deficiencies on several crops in North Dakota and in Minnesota. Sulfur is generally known to be a problem on coarse textured sandy soils with low organic matter; therefore historically it was not a concern to many growers in this region. The fact that sulfur deficiencies of crops in the area have been on the rise can be attributed to several factors. Sulfur is a mobile element that, in its plant available form, will leach easily, similarly to nitrates. In the past, there were significant amounts of sulfate deposited through air pollution, impurities in fertilizers, herbicides and pesticides. With a decrease in air pollution, and with improved purity of agricultural chemical products, these sources of sulfur have now become less important. Soil organic matter (SOM), which contains at least 90% of plant available sulfur in the soil, remains the most important source of sulfur. Yield increases in recent years, and in some cases, loss of SOM could also have contributed to sulfur limitations of crops.

Currently, one of the serious challenges to sulfur fertility management is prediction of wheat response to sulfur application based on soil test recommendation. A 10 site-year study from Canada reported that due to very low overall crop response, sulfur fertilization was not economical on spring wheat in that region (Karamanos et al., 2013). Most of the sites included in that study had SOM higher than 3% with one of them as high as 10.7%. While SOM content in the Great Plains is considered one of the highest in the U.S., most soils in North Dakota still only have 2-5% (Dahnke and Swenson, 1979) and Minnesota also has considerable farmland with less than 3% SOM. Leaching of available sulfur in early spring can also cause sulfur deficiency. For this reason there are several areas where sulfur response can be expected.



In previous years we have observed sulfur deficiencies on wheat in and around Carrington, North Dakota. A wheat sulfur response study in Carrington (Teboh and Zilahi-Sebess, 2014) that received blanket N at 150 lbs/ac, showed that a 10 lbs/ac sulfur application increased grain yields by 7 bushels over the control and also increased the protein content of the grain. The application of 10 lbs sulfur resulted in $63.18/ac net increase in income and an additional 10 lbs S raised the net return additional $6.41/ac. These numbers were obtained using local fertilizer prices and market values and protein premiums for spring wheat in November 2014. The SOM content at the trial site was 4% and the soil sulfur result showed 80 lbs S/ac in the 0-24 inch depth prior to planting. This sulfur test level is considered very high and according to the MN and ND guidelines for sulfur fertilization, additional sulfur would not be recommended for this loam soil, and at this level of SOM. Sulfur testing on heavier soils with high organic matter is an unreliable predictor of yield response (Rehm and Schmitt, 1989) while SOM content and texture have been reported as better predictors for some soils in Iowa (Sawyer et al., 2012). The fact that we still had such a strong response to sulfur even though the SOM content was high at this site might be due to leaching from of available sulfur with the melting of large amounts of snow in 2014, or possibly due to the low rate of mineralization caused by prolonged cool soil temperatures.

Current sulfur recommendation is at 25 lbs/ac at planting as insurance on a coarse textured soil, where sulfur deficiencies have been observed before.

At an adjacent wheat nitrogen study using the same variety where no sulfur was applied, yields were maximized at 70 lbs N, producing 70.8 bu/ac, and protein was maximized at 105 lbs N rate. There was a negative response to further N rates. In the sulfur trial the 150 lbs N rate yielded 64.2 bu/ac, whereas the 150 lbs N with the 20 lbs S/ac treatment yielded 71.6 bu, higher than the maximum yield of the other trial. The protein content was also increased with S. However, the increase in yield and protein in response to 150 lbs N with sulfur application was not enough to make it economical to apply such a high rate of N. What this data shows though, is that yield and protein response to N rates was extended with the addition of sulfur. There are studies that show that sulfur increases nitrogen use efficiency (Salvagiotti, 2009) and it would be important to pinpoint the best N to sulfur fertilizer ratio and levels for optimizing spring wheat performance for maximum economic return.

This study aims to provide update on the judicious management of sulfur in combination with N on spring wheat, to reach optimum yields and better grain quality.

Procedures: The trial will be conducted on farmers' fields at two locations where wheat production is very important to the producers, close to northwestern Minnesota. Nitrogen and sulfur fertilizer treatments will be randomly assigned to plots arranged in a split plot design with five N rates as main plots for a total soil N of 60, 120, 180, and 240 lbs per/ac, plus a check (0 N added). Three sulfur rates (0, 10, 20 lbs/ac) will be imposed as sub-plots on each N main plot for a total of 15 treatments. Each treatment will be replicated four times. Each sub-plot will be 30 x 15 ft sq. The 10 and 20 lbs S rates are included in the N check plot to assess if there may be detrimental effects associated with high S in plots where yield potential is low, and as well to facilitate statistical analysis. By applying S up to 20 lbs, we are attempting to eliminate any chances of not seeing a plateau of either yield or protein in response to S rates. Secondly, we will be able to answer the question whether any increase in yield or protein content is to be expected when applying sulfur above the 10 lbs rate, and whether that rate would be profitable to apply. Soil samples will be taken before planting to determine nutrient status. Recommended agronomic practices would be employed based on the producer's normal farm practices regarding herbicide and pesticide applications. Nutrients, other than those being tested, will be supplied based on soil test levels. Leaf tissue samples will be collected at flag leaf and at anthesis from each plot and then composited by treatment before drying (at 65°C) for N and sulfur analysis. These results will inform us of the sulfur status and N to S ratio that we may expect if a producer decided to use mid-season leaf testing to determine if their crop would need additional sulfur. Furthermore, we will determine by how much the S demand has changed from the flag leaf stage through anthesis. Plant vigor will be evaluated based on NDVI measurement with a pocket GreenSeeker™ sensor right before flag leaf sampling. Grain yields and protein content will be recorded. Grain samples will be analyzed for sulfur and N following harvest.

Regional Linkages to Other Research Activities: None at the time the proposal was prepared.

Research group: Jasper Teboh (Soil Scientist) and Szilvia Zilahi-Sebess (Soil Research Specialist)

Relationship to past projects: The main objective of this study has not been researched in Minnesota in recent decades.

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 summer students who will assist in trial maintenance and data collection. Fringe benefits are calculated at 35% for research specialists and technical staff and 10% for pre-baccalaureate students. Funding for materials and supplies includes fuel, fertilizer, herbicides, plot supplies and repair supplies for routine maintenance of equipment. Travel funding is requested for travel to and from the trial sites. Other direct costs are analyses fees.

List current or potential other funding sources for this project: No additional sources of funding have been requested at this time.

References:

Dahnke, W.C., and L.J. Swenson. 1979 N status of North Dakota. Farm Research. Vol 37, No 3.

Karamanos, R.E., J.T. Harpiak, and N.A. Flore. 2013. Sulphur application does not improve wheat yield and protein concentration. Can. J. Soil Sci. 93: 223-228.

Rehm, G., and M. Schmitt. 1989. Sulfur for Minnesota soils. University of Minnesota/Extension. Available online at http://www.extension.umn.edu/agriculture/nutrient-management/secondary-macronutrients/docs/AG-FO-0794-1.pdf

Salvagiotti, F., J. Casterllarin, D. Miralles, and H. Pedrol. 2009. Sulfur fertilization improves N use efficiency in wheat by increasing N uptake. Field Crops Research. 113: 170-177.

Sawyer, J.E., B. Lang, and D.W. Barker. 2012. Sulfur fertilization response in Iowa corn and soybean production. Proceedings of the 2012 Wisconsin Crop Management Conference, Vol. 51. 39-48.

Minnesota Wheat Research and Promotion Council
RESEARCH PRE-PROPOSAL BUDGET

PROJECT TITLE: The economics, nitrogen use efficiency, and wheat performance in response to sulfur and nitrogen fertilizer levels and their interaction

Principal Investigator(s) / Project Directors(s) **Jasper Teboh**	Funds Requested For Year 1 (2015)	 Year 2 (2016)	 Year 3 (2017)
A. Salaries and Wages	$	$	$
1. Co-principal Investigator(s)			
2. Senior Associates			
3. Research Associates - Post Doctorate			
4. Other Professionals	3,500		
5. Graduate Students			
6. Prebaccalaureate Students	1,000		
7. Secretarial - Clerical			
8. Technical, Shop and Other	5,092		
B. Fringe Benefits @ 35% for professionals, technical; 10% for prebaccalaureate students	3,107		
C. Nonexpendable Equipment (Planting and harvesting equipment use)			
D. Materials and Supplies	3,551		
E. Travel	1,950		
F. Publication Costs			
G. Computer Costs			
H. All Other Direct Costs (Attach supporting data)	4,139		
TOTAL AMOUNT OF THIS REQUEST (per year)	**22,339**		

H. All Other Direct Costs
Flag-leaf biomass N and S analyses – 15 composite samples x 2 locations x $21.90/sample = $657
Anthesis N and S analyses – 15 composite samples x 2 locations x $21.90/sample = $657
Grain N and S analyses – 60 samples x 2 locations x $21.90/sample = $2,628
Soil sampling – 2 locations x $38.50 = $77
Grain protein analysis – 120 samples x $1/sample = $120