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: Regents of the University of Minnesota
Address: Sponsored Projects Administration
454 McNamara Alumni Center, 200 Oak Street SE
Minneapolis, MN 55455-2070

2. TITLE OF PROPOSAL
Maximizing Canopy Conductance to Enhance Spring Wheat Yield Potential in the Upper Midwest

3. PRINCIPAL INVESTIGATOR(S)
Walid Sadok

PI# 2 Name: Brian Steffenson

PI# 3 Name: James Anderson

4. PI #1 BUSINESS ADDRESS
Department of Agronomy and Plant Genetics
411 Borlaug Hall
1991 Upper Buford Circle
St. Paul, MN 55108

5. PROPOSED PROJECT DATES (calendar years)
January 1st, 2017 – December 31, 2018
Note: Research Reports are Due November 15th of Each Year

6. TOTAL PROJECT COST
$36,954

7. PI #1 PHONE NO.
612-625-8291

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

There are very few reliable and accessible traits that are strongly associated with increased wheat productivity. We have recently identified increased canopy conductance as a promising novel trait that is linked to yield increases in wheat in Minnesota between 1992 and 2016, making it a particularly valuable target for a breeding program. Because this trait is challenging to measure, we have successfully developed a novel 'precise phenotyping' system that will enable the screening of hundreds of wheat plants per week for canopy conductance. Using the recently developed Minnesota Nested Association Mapping Population (MNAMP), our first goal is to leverage the platform to characterize the diversity in canopy conductance within a diverse group of parents, consisting of the recurrent cultivar RB07 and 25 exotic MNAMP parents. Our second goal is to phenotype, for the first time, an entire mapping population resulting from a cross between RB07 and the most exotic parent exhibiting the most extreme differences for canopy conductance. Our third and final goal for this year is to conduct a genetic analysis that would reveal quantitative trait loci (QTL) and genetic markers associated with enhanced canopy conductance in wheat. Those markers will be highly valuable to introgress genes controlling enhanced canopy conductance in the University of Minnesota wheat breeding program and ultimately, in other breeding programs across the region.

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** 01/09/2017	**Phone Number** 612-625-8291
Signature Of Authorized Representative	**Title** Kevin McKoskey, Director Sponsored Projects Administration	**Date** 1/11/17
Address Of Authorized Representative Kevin McKoskey, Sr. Associate Director, Office of Sponsored Projects Administration 450 McNamara Alumni Center, 200 Oak Street SE, Minneapolis, MN 55455-2070		**Phone Number** 612-624-5399

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

Project Title: Maximizing Canopy Conductance to Enhance Spring Wheat Yield Potential in the Upper Midwest

Importance of this project to the profitability of wheat producers:

Grain yield and protein content are two of the most important traits for Minnesota wheat growers. However, despite the recent progress in breeding and management, further improvements have been difficult to achieve because high yielding cultivars tend to have lower grain protein. Breaking the ceiling dictated by this relationship requires the discovery of novel traits that allow for increases in both carbon and nitrogen (N) available to the seed. Recently, the principal investigator's group has assembled evidence indicating that maximizing whole-plant canopy conductance would allow for maximizing the amount of carbon (as CO_2) and N fixed by the plant, which in turn would lead to increasing grain yield and protein content. The principal investigator's group found that this conductance strongly correlated with historic wheat yield increases achieved in Australia between 1895 and 2008, during which yields increased by more than 400% (Schoppach et al. 2017). We have confirmed this observation on Minnesota-grown wheat in an experimental setting where we examined whole plant canopy conductance for 17 spring wheat genotypes released in Minnesota between 1992 and 2016. Those genotypes exhibited a significant increase in canopy conductance that correlated with historic increases in wheat yield in Minnesota and also tracked increases in grain protein. Such findings indicate that enhancing canopy conductance of Minnesota wheat would be an excellent target for a wheat breeding program. Our near-term goal is to identify and introgress the genes controlling this trait in a wheat breeding program to deliver superior, more profitable cultivars that will enhance yield and grain protein without the need to increase current N nitrogen application rates.

Procedures:

Wheat leaves are covered with small pores called stomata through which they lose water by transpiration and fix carbon dioxide (CO_2) needed for photosynthesis. Canopy conductance is a physiological trait that measures how much water is being removed from the soil by leaf transpiration and 'traded' for CO_2 fixed by the leaf through stomata. 'High conductance' genotypes are therefore able to maximize the amount of water and nutrients, particularly N-uptake from the soil, fix more CO_2 to fuel photosynthesis and increase seed filling while maintaining the canopy at the optimal temperature through transpirational cooling.

Traditional measurement of whole-plant canopy conductance is a time-consuming, low-throughput approach that requires a strong control of interfering environmental variables. To circumvent these limitations, the principal investigator, Dr. Walid Sadok has invested in the development of a $77K high-throughput 'precise phenotyping' system that is able to screen whole-plant canopy conductance for hundreds of wheat plants per week under controlled conditions. This system enables the identification of genotype-specific responses that are relevant to field conditions, but cannot be easily and rapidly detected there because of substantial environmental noise such as passing clouds and instantaneous variation in wind speed which can alter canopy conductance.

Using this system, canopy conductance is measured as the slope of the relationship between progressive increases in atmospheric vapor pressure deficit (VPD) and water loss by the entire plant measured by tracking pot weight change measured by scales connected continuously to data loggers. Increases in VPD generate a 'negative pressure' that forces water out of the stomata, and the relationship between VPD and pot weight change will allow us to quantify with high precision the plant's conductance to water. The increase in VPD imposed in the growth chamber mimics VPD conditions that would typically take place under a sunny, cloudless summer day in the field. This system was successfully tested on Minnesota wheat genotypes released between 1992 and 2016 and is an automated version of the system used by the PI's group to demonstrate for the first time the strong link between Australian wheat yields increases and canopy conductance enhancement (Schoppach et al. 2017).

During the first year of this project, our goal will be to leverage this system to phenotype an entire mapping population and identify, for the first time, quantitative trait loci (QTL) and genetic markers controlling whole-plant canopy conductance in that population. In order to maximize our chances to identify such loci and associated genetic markers, we will carry out the phenotyping effort on the Minnesota Nested Association Mapping Population (MNAMP), which was recently developed by Brian Steffenson through a project funded by the MWR&PC. The MNAMP population is superior to more conventional methods for identifying QTL because it was designed to optimize allele richness, maximize mapping resolution and statistical power.

In a first step, we will initially use the phenotyping system to evaluate a highly diverse germplasm panel, consisting of the recurrent parent RB07 and 25 wheat accessions selected as the exotic parents for the MNAMP. During this phase, we will analyze transpiration response curves to increasing VPD of all individual plants and quantify whole-plant conductance for each genotype. This experiment will be replicated twice in order to obtain robust results. Second, we will use the phenotyping system to characterize conductances of 140 F5-derived recombinant inbred lines (RILs) resulting from the mating of recurrent parent RB07 and the exotic parent with the most extreme conductance. These RIL lines were previously phenotyped in the field for several agronomic traits, and they were also genotyped at a high resolution with the genotyping by sequencing method.

In a final step, we will analyze the conductance data in relation to genetic marker information provided for each individual of the population in order to identify QTL controlling conductance. The genetic analysis is expected to reveal for the first time genetic regions and markers that are associated with alleles conferring enhanced canopy conductance in wheat.

Regional linkage to other research activities:
Because improved canopy conductance could potentially contribute to enhancing nutrient acquisition from the soil, increasing grain protein and tolerance to other stresses, this project will lead to creating strong links with other projects addressing those aspects throughout the region. For instance, the phenotyping system would benefit the NDSU HRSW breeding program because canopy conductance is strongly related to key goals of the program such as enhancing drought and heat stress tolerance. In addition, superior genotypes with particularly enhanced canopy conductance will be shared with other wheat breeding programs in the region.

List current or potential other funding sources for this project:
The PI is currently co-leading an international project which will leverage canopy conductance traits to increase wheat productivity in North Africa.

Research Group:
Brian Steffenson will deliver seed of the MNAMP and all genotype data for conducting the genetic analysis of canopy conductance. Jim Anderson will contribute to the genetic analysis and QTL identification.

Relationship to past projects:
The PI has collaborated in the past with Australian wheat breeders and genomicists and successfully identified canopy traits that led to improving wheat productivity under drought conditions.

Estimate the budget requirements:
Funding is requested for a 50% postdoc (salary: $24,213 and fringe: $4,867 at 20.1%) and for greenhouse and 3 growth chamber rental costs needed for the phenotyping effort ($7,874).
Through startup funding, Dr. Sadok will support a technician position ($40,000) and 50% of the postdoctoral researcher position ($29,080) to carry out this work. Dr. Sadok will use a high throughput phenotyping platform that he developed at a cost of $77,192. Thus, the total in-kind funding and contributions are $146,272.

References:

Schoppach R, Fleury D, Sinclair TR, **Sadok W**. 2017. Transpiration Sensitivity to Evaporative Demand across 120 Years of Breeding of Australian Wheat Cultivars. Journal of Agronomy and Crop Science (in press, doi:10.1111/jac.12193).

Minnesota Wheat Research and Promotion Council

RESEARCH PROJECT PROPOSAL BUDGET

PROJECT TITLE:			
Principal Investigator(s) / Project Directors(s)	Funds Requested For		
	Year 1 (2017)	Year 2 (2018)	Year 3 (2019)
A. Salaries and Wages	$	$	$
1. Co-principal Investigator(s)			
2. Senior Associates			
3. Research Associates - Post Doctorate	$24,213		
4. Other Professionals			
5. Graduate Students			
6. Prebaccalaureate Students			
7. Secretarial - Clerical			
8. Technical, Shop and Other			
B. Fringe Benefits	$4,867		
C. Nonexpendable Equipment (Planting and harvesting equipment use)			
D. Materials and Supplies			
E. Travel			
F. Publication Costs			
G. Computer Costs			
H. All Other Direct Costs (Attach supporting data) Greenhouse and growth chamber rental fees	$7,874		
TOTAL AMOUNT OF THIS REQUEST (per year)	**$** 36,954	**$**	**$**