



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, 450 McNamara Alumni Center, 200 Oak Street SE, Minneapolis, MN 55455-2070		
2. TITLE OF PROPOSAL Breeding to boost seed-filling and increase Minnesota wheat yields		
3. PRINCIPAL INVESTIGATOR(S) PI# 1 Name: Walid Sadok <hr/> PI# 2 Name: Xiaoxing Zhen <hr/> PI# 3 Name: James A. 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 1, 2024 – December 31, 2024 Note: Research Reports are Due November 15th of Each Year	6. TOTAL PROJECT COST \$36,848	7. PI #1 PHONE NO. 612-625-8291
8. RESEARCH OBJECTIVES: (List objectives to be accomplished by research grant) Our main goal is to support the wheat breeders in the region deliver higher-yielding wheat varieties. In the proposal, our specific objective is to boost the rate of seed-fill to increase yields, by increasing flag leaf photosynthesis. This is based on evidence assembled by our team showing that rising flag leaf photosynthesis during seed-fill (but not necessarily in all in other stages), co-trends with historical wheat yield increases across the globe. To this end, our project has two main objectives for this year. In a first step, our research program will start by screening a wide range of breeding lines to identify lines that express superior photosynthesis during seed-fill, and assemble a population of lines that express high diversity in this response. In a second step, we will target the development of a high-throughput technique for detecting this difference on a much larger number of genotypes in the field. 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 12.26.2023	Phone Number 612-625-8291
Signature Of Authorized Representative 	Title Principal Grant and Contract Officer	Date 1/2/2024
Address Of Authorized Representative Riana Fletcher, Office of Sponsored Projects Administration 450 McNamara Alumni Center, 200 Oak Street SE, Minneapolis, MN 55455-2070		Phone Number 612-624-2038

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RESEARCH PROPOSAL GRANT APPLICATION

(2-pages maximum)

Project Title: Breeding to boost seed-filling and increase Minnesota wheat yields

Importance of this project to the profitability of wheat producers:

Seed-fill is the 'money-making' window for wheat growers. During this critical phase of the crop's growth, the wheat plant invests aggressively all of the carbohydrates and nitrogen that are available to fill the developing grain with nitrogen, starch and other nutritional factors. We have recently identified a novel trait that has the potential to increase the rate of wheat seed-fill and therefore increase wheat yield, and possibly, grain protein. In a study that we have recently submitted to a peer-reviewed international journal, we have conducted a worldwide analysis of wheat yield from 1890 to 2019 in 5 continents and found that increases in flag leaf photosynthesis during seed-fill was the best predictor of historical yield increases globally. Increasing photosynthesis during that window likely contributed to yield increases by enabling a higher rate of trans-location of proteins and other nutritional factors to the developing seed. This discovery supports the evidence indicating that healthier, disease-free flag leaves are a critical determinant of wheat yields. Based on this new discovery, our goal is to support the U of M wheat breeding program by developing a selection pipeline to identify breeding lines with superior photosynthesis during seed-fill. To the best of our knowledge, this is the first time a breeding program will intentionally target the goal of 'boosting' seed-fill photosynthesis. Our estimation, based on historical trends, is that rising seed-fill photosynthesis in modern commercial lines may increase yields by at least 15%.

Procedures:

In a first step, our research program will start by screening a wide range of breeding lines to identify lines that express superior photosynthesis during seed-fill, and assemble a population of lines that express high diversity in this response. In a second step, we will target the development of a high-throughput technique for detecting this difference on a much larger number of genotypes in the field.

During the first year, we will focus on the first step. To this end, we will assemble a diverse set of 30 lines consisting of i) check cultivars (Shelly, Linkert, MN-Torgy, MN-Rothsay), ii) varieties with different years of releases and iii) a selection of highly diverse advanced breeding lines. These genotypes will be field-planted in yield plots (approx. 4 ft. X 9 ft.) at the U of M St Paul campus, using a randomized complete block design with three replications. Plots will be managed per the typical management practices.

Flag leaf photosynthesis measurements will be conducted at solar noon on sunny days using a portable photosynthesis system (LiCOR 6800). This sophisticated machine will make it possible to measure in the flag leaf's photosynthesis in the field while controlling for environmental fluctuations such as light, windspeed, temperature and humidity. Due to the time-consuming nature of these measurements, we will dedicate three LiCOR 6800 machines to conduct these measurements (3 users simultaneously). These will take place several times during the season, starting at the flowering, milk, soft dough and hard dough stages.

In parallel to these photosynthesis measurements, we will track leaf nitrogen (N) status at these phenological stages in order to quantify the rate of N remobilization to the seed. Additionally, we will measure leaf greenness both proximally and remotely. The proximal measurement consists of using a small hand-held machine (SPAD) that clamps on the leaf to measure its greenness. The remote-sensing approach will rely on scanning the entire canopy using an RGB (Red-Green-Blue) camera mounted on an unmanned aerial system (UAS; Inspire 2, DJI). These greenness measurements represent indirect measurements of photosynthesis, and therefore they are less precise, but are much faster to perform. By using them, our goal is to evaluate their potential for higher-throughput screening of seed-fill photosynthesis. This will be the case if a significant correlation is found between flag leaf photosynthesis during seed-fill and canopy greenness is identified.

Regional linkages to other research activities:

This research builds directly on a successful project previously funded by the MWR&PC, which goal is to develop a remote sensing pipeline for screening wheat breeding lines for their canopy health. We will rely on this pipeline for screening wheat genotypes for their flag leaf greenness as detailed in the previous section. Furthermore, the trait investigated in this research is likely to be useful to what growers across the entire region (MN, SD, ND). In fact, the research at the basis of this proposal suggests that this trait is useful in all wheat growing regions across the globe. Therefore, we will use wheat varieties cultivated across the entire region in our research.

List any other secured, pending, or planned submissions to outside funding sources for this work:

Anderson and Sadok have received funding for a graduate student from USDA-NIFA. This funding will support a graduate student who will start in the fall of 2023/spring of 2024. The student is expected to participate UAV-based remote-sensing efforts, which should enable us to deploy our technology on a larger number of trials.

Research Group:

The research group consists of co-PIs whose name is already listed.

Relationship to past projects:

This research will take advantage of the progress achieved from a successful project previously funded by the MWR&PC, which goal is to develop a remote-sensing pipeline for screening superior wheat genotypes. We will use the ability of our remote-sensing pipeline for screening genotypes for their canopy greenness as a tool for potentially screening genotypes for their flag leaf photosynthesis.

This research also builds on another previously funded project where we identified the genetic basis of canopy conductance in MN wheat, published in a peer-reviewed scientific journal (Tamang et al. 2022). If genetic variability for flag leaf photosynthesis is confirmed, then we can expect to apply the same approach for identifying the genetic basis of this trait based on Tamang et al. (2022).

Estimate the budget requirements:

0.5 FTE Salary (\$27,417) and fringe (at 27.1%, \$7,430) to support the postdoctoral research associate who will lead measurement campaign, analyze data and prepare reporting (total salary cost: \$34,848). \$2,000 will be needed to perform N quantification of the flag leaf. Total cost is \$36,848.

References:

Tamang, B. G., Monnens, D., Anderson, J. A., Steffenson, B. J., & Sadok, W. (2022). The genetic basis of transpiration sensitivity to vapor pressure deficit in wheat. *Physiologia Plantarum*, 174(5), e13752. doi:10.1111/ppl.13752

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RESEARCH PROJECT PROPOSAL BUDGET

Project Title: Breeding to boost seed-filling and increase Minnesota wheat yields			
Principal Investigator(s) / Project Director(s) Walid Sadok, Xiaoxing Zhen, James A Anderson	<u>Funds Requested For</u>		
	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	\$27,418		
4. Other Professionals			
5. Graduate Students			
6. Prebaccalaureate Students			
7. Secretarial - Clerical			
8. Technical, Shop and Other			
B. Fringe Benefits	\$7,430		
C. Consulting and Professional Services			
D. Supplies and Services	\$2,000		
E. Travel			
F. Sub-Contracts			
G. Repairs & Maintenance			
H. Rentals & Lease			
I. Other Expenses			
TOTAL AMOUNT OF THIS REQUEST (per year)	\$36,848	\$	\$

Approved Brian Sorenson Int'l: _____ Date: _____