Minnesota Wheat Research and Promotion Council
FULL RESEARCH PROPOSAL TEMPLATE
For Crop Year 2026 (01/01/2026 to 12/31/2026)

(Maximum Two Pages, Plus Itemized Budget)

Please Note: To speed up and streamline the granting process, we now require full proposals to be submitted by 11:59 PM CST on November 15, 2025. You will need to include an itemized budget with your proposal that has been approved by your organization's accounting and/or sponsored programs department.

Project Title: **A field high-throughput screen to breed for faster N remobilization and higher MN wheat yields**

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Project Period: 1/1/26 – 12/31/26
Estimated cost: $36,616

Abstract

Increasing yield and seed protein content is key to any wheat breeding program. Previous research conducted on 30 MN wheat varieties released between 1915 and 2022 has shown that a 4x yield increase achieved during that window is associated with high rates of photosynthesis and leaf nitrogen (N) remobilization towards the grain. This means that achieving higher yields will have to target improving these two processes. The challenge, however, is that direct measurements of these two traits are time consuming and do not make it possible to screen thousands of lines that make up a breeding pipeline each year. Here, we propose a novel screening method that is based on a strong association we discovered between leaf N and photosynthesis on the one hand and its chlorophyll concentration on the other hand. The proposed method is nondestructive and rapid (3s), making it possible to screen -in theory- thousands of genotypes per day. Our goal is to develop a phenotyping pipeline using this method on a set of 75 highly diverse wheat varieties and breeding lines (the UMN statewide variety trial), which we will then scale up to screen a much larger number of genotypes after validation. If successful, this project will enable breeding to boost traits that drove historical MN wheat yield increases. This in turn will lead to higher yields and increase wheat grower's economic returns.

Describe the background for your proposed project and the importance of this project to the profitability of wheat production in MN: Increasing wheat yields while improving or maintaining seed protein concentration is one of the main goals of the U of MN wheat breeding program. Recently, thanks to research supported by the Minnesota Wheat Research and Promotion Council, we have examined the physiological drivers of historical wheat yield increases in Minnesota over a century of breeding. We have discovered that quadrupling yields during that period was associated with an increase in the ability of varieties to maintain high rates of photosynthesis during seed fill while accelerating the remobilization of nitrogen (N) compounds from leaves towards the developing seeds. This discovery illuminates a mechanism for increasing yield that could be harnessed by breeders to continue or further accelerate yield genetic gains. However, for purely breeding purposes, measuring photosynthesis and leaf N are not realistic. Photosynthesis measurements are time consuming (5 min. per measurement) and leaf N quantifications are destructive and cost prohibitive. These two bottlenecks make it impossible to use leaf N and photosynthesis as high-throughput phenotypic screens.

An exciting development of our research is our discovery of a new screening approach that is much cheaper and potentially high throughput, which we propose to develop in the proposed investigation. This

approach consists of rapid and nondestructive measurements of the rate of degradation of chlorophyll. This idea is based on a highly significant ($P < 0.0001$) and strong ($R^2 = 0.69$) association between flag leaf chlorophyll content and photosynthesis based on > 1600 field-based observations. Critically, while a single photosynthesis measurement requires stabilizing the leaf for 300s, measuring chlorophyll content will take no more than 3s, that is, 100x faster. This discovery offers a unique opportunity to support the U of MN wheat breeding program by potentially enabling the routine screening of hundreds or thousands of breeding lines during seed fill to increase yield and seed protein. Our goal for this project is to develop and validate such a method.

Research methods: In this first year, the goal will be to develop this method on a set of a highly diverse genetic material in one location, before expanding the protocol to screen a much higher number of genotypes in 2-3 locations. To this end, we will screen a total of highly diverse 75 genotypes developed by the U of MN wheat breeding program. These will include popular varieties MN-Torgy, MN-Rothsay and other breeding lines that contrast for their yield potential and protein content. These varieties will be planted in yield plots (approx. 4 ft. X 9 ft.), using a randomized complete block design with three replications. Plots will be managed per the typical management practices. Heading date, grain yield, its main component traits, including seed protein content will be measured. Flag leaf chlorophyll measurements will be conducted using portable chlorophyll meters, a first time at heading, and a second time during ripening at the soft dough stage. Those measurements will be collected on 6 plants per plot each time. A rate of chlorophyll decline will be computed based on these two measurements and this rate will be used as a proxy for the rate of remobilization of leaf N towards the developing seed and maintenance of CO_2 fixation. A first set of measurements will be conducted to test whether these chlorophyll measurements vary as a function of the time of the day or of variation in weather conditions such as temperature and light. This test is essential as it could enable an even higher throughout for screening if such variation does not influence chlorophyll content. This means a substantial increase in the possible number of genotypes that can be screened, as measurements are not constrained by weather or time of the day as is the case for photosynthesis measurements. Finally, we will use a drone-based approach to test whether canopy greenness measured remotely using an RGB camera correlates with chlorophyll measurements. This remote-sensing method is much less precise but faster. Data analysis will be conducted to examine association between the rate of chlorophyll decline and yield and protein and its correlation with remotely-sensed Green Area Index.

Outline the timeline for completion: Jan.-March 2026: Assembling genotypes, preparing equipment. April-Aug. 2026: planting, plant husbandry and collecting field data. Sept.-Dec. 2026: analyzing the data and reporting.

What methods, if any, will be used to disseminate your research findings out to the greater public, beyond the final report due to Minnesota Wheat Research and Promotion Council: We will share our findings with growers at venues such as the Winter Prairie Grains Conference. Upon completion of the project, we will also provide updates through the University of Minnesota Extension portal, as well as through ad hoc meetings and field days for growers and other agricultural professionals. To reach the broader scientific community, we will present our results at major conferences, including the Crop Science Society of America meetings. We anticipate that this research will produce publishable outcomes suitable for leading scientific journals with wide and diverse readerships, such as Crop Science or Agronomy Journal.

List potential collaborators or co-investigators you may consider inviting to participate: The main collaborator identified is the co-PI on this project, U of MN wheat breeder Jim Anderson (Agronomy & Plant Genetics).

Budget requirements: 0.4 FTE technician salary and fringe ($31,752). Technician will, track plant phenology, coordinate measurement campaign, conduct drone flying, chlorophyll measurements, analyze all data and supervise undergraduates. Undergraduate students' temp casual salary ($16/hr) for 50 hrs ($864 with 8% fringe) to support field measurements. Supplies for drone and chlorophyll measurements (batteries, software analysis, back-up cholorophyll meter): $4,000. Total: $36,616.

Submit full proposal (max. 2 pages) and itemized budget to bsorenson@mnwheat.com by 11:59 PM, 11/15/25