

Grant Code: AP4535
TITLE: Developing Wheat Cultivars for Idaho
PERSONNEL: J. Chen, J. Wheeler, N. Klassen, J. Bevan, R. Chowdhury, M. Su, J. Pabitra
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JUSTIFICATION:

Idaho wheat production contributes significantly to domestic and overseas wheat markets. Nationally, Idaho ranks in the top eight states for wheat production. Most wheat production in southeastern Idaho is grown under irrigation, while in northern Idaho it is grown under dryland conditions. Improved grain yield and end-use quality are the two primary traits required for new wheat cultivars. Resistance to biotic and abiotic stresses greatly impact on grain yield and end-use quality. Stripe rust has been the most important disease in both winter and spring wheat as it occurs frequently and causes significant yield and quality losses for growers and the wheat industry. Fusarium head blight (FHB) has emerged in irrigated production areas, especially for spring wheat, due to increasing corn production, no-till practices, and the climate change. Most wheat cultivars are highly susceptible to FHB. When an epidemic occurs, the fungus in the infected grains will produce a toxin called DON which causes grain to be unusable for human consumption and animal feeds. Dwarf bunt is an endemic disease in high elevation dryland production areas. Because of dwarf bunt, only certain wheat varieties can be grown in these areas without costly seed treatments. Other diseases and pests affecting wheat production in Idaho include Hessian fly, barley yellow dwarf virus (BYDV), bacterial leaf blight, physiological leaf spots, dryland crown rot, cereal cyst nematodes, and wireworm. Drought and heat are the main abiotic stresses. Pre-harvest sprouting and late maturity alpha amylase damage have also become production concerns in recent years. To sustain Idaho's status as a consistent high-quality wheat provider, we must continually address these production concerns by applying cutting-edge breeding technologies to cultivar development.

RESEARCH HYPOTHESIS & OBJECTIVES: The genetic recombination of desired genes can be achieved by crossing, selfing, mutation, and gene editing. Selection within segregating populations can be enhanced by using molecular markers and by growing breeding populations in representative production environments favorable for trait expression. The breeding process can be accelerated using a proper combination of traditional breeding methods and new breeding technologies. The objective of this study is to develop adapted premier wheat cultivars using a combination of traditional and genomics-assisted breeding methods.

1. BREEDING ACTIVITIES and PROCEDURES:

- 1.1. Marketing and Variety Release:** assist in marketing released cultivars (UI Stone, UI Platinum, UI Sparrow, UI Bronze Jade, UI Cookie); release one or two strong gluten hard white spring cultivars (IDO1804S and IDO2002S) in 2021. IDO1708 (SWW) and IDO1702S (SWS) are ready to release once the partners are identified.
- 1.2. Breeder Seed Production:** plant breeder seed increase in plots for IDO1906 (HWW), IDO1404S (SWS), IDO1902S (SWS), IDO1804S (HWS), IDO1904S (HWS); plant

breeder seed in headrow plots for IDO2006 (HWW), IDO2008 (SWW), three hard white spring wheats (IDO2002S, IDO2004S, IDO2104HF); two FHB resistant wheats (IDO2101FHB and IDO2103FHB) and two CL plus hard red spring wheats.

1.3. Elite and Breeding Line Evaluation: Yield trials are defined previously as Elite Yield Trial (EYT), Preliminary Yield Trial (PYT), and Observation Yield Trial (OYT). The OYT is the first year, non-replicated trial planted in one or two environments depending on seed availability. The PYT is the second year, replicated yield trial usually planted in two or three environments. The EYT is the third year, replicated yield trial planted in four to seven locations in SE ID. Lines in the EYT will be evaluated for stripe rust by Dr. X. Chen, dwarf bunt by Dr. David Hole, FHB by Dr. Steve Xu and ourselves, stem rust by Drs. Yu Jin and Matt Rouse, snow mold by Dr. J. Marshall, and Hessian fly by Dr. Arash Rashed. Elite lines will also be genotyped with known functional markers by Dr. D. See at the ARS genotyping center at WSU and in our marker assisted selection (MAS) lab. After harvesting the EYT, PYT, and OYT from multiple locations, end-use quality of the selected lines will be assessed in the Idaho Wheat Quality Lab. Yield, agronomic, disease and insect resistance, and marker data will be used to select lines for crossing and further evaluation in the Western Regional Trials and State Variety Trials in the following years.

1.4. Headrow Evaluation: Headrows will be planted in Aberdeen, ID and assessed for plant type, other agronomic characteristics, and disease resistance. After harvest, test weight, seed color, protein, and flour hardness will be assessed and used to select entries for the next OYT. Headrow trials are also used for seed increase of F1 and special genetic materials such as EMS mutant lines and near iso-genic lines derived from basic research.

1.5. Early Generation Test (F2, F3, and F4): We will focus on evaluation of agronomic traits and resistance to stripe rust and bacteria leaf blight and advance populations using a modified bulk breeding method.

1.6. Objectives for 2022 New Crosses: Continue backcrossing Hessian fly resistance gene *H26*, a new FHB resistance gene from synthetic wheat, and *FHB 7* into elite lines of winter and spring wheat. Introgression of LMA and low Cd into more elite line backgrounds. Top- or backcross for strong gluten and resistant starch in spring wheat. Top- or backcrossing for yield components in spring wheat. Develop CL PLUS soft spring and soft winter wheat.

2. Molecular Marker Assisted Breeding:

2.1. Use KASP markers and a gel-based marker system in our lab and the service under Western Regional Genotyping lab.

2.2. Lines from the EYTs and crossing parents will be genotyped.

2.3. Traits that can be accessed via molecular markers include: FHB, Hessian Fly (*H25* and *H26*), height, vernalization, heading, baking quality, dwarf bunt, stem rust (*Sr2*, *Sr39*, *Sr47*), LMA/PHS, yield components, and resistant starch.

3. Marker Development and Validation and Other Basic Research:

3.1. Develop desirable storage protein profile for strong gluten hard white wheat (in collaboration

with a USDA-ARS lab).

- 3.2. Breed durable and high level of dwarf bunt resistance using molecular marker-assisted selection (separate proposal).
- 3.2. Validate, characterize and deploy QTL for grain yield components in wheat (USDA-ARS NIFA Wheat CAP).
- 3.3. Develop FHB resistant spring wheat via MAS and genomic selection (USDA-ARS USWBSI project).

4. Other Collaborative Research Projects:

- 4.1. Grow H26 yield trial in collaboration with Dr. Steve Xu.
- 4.2. Grow State Variety Trial for winter wheat in Rockland for Dr. Juliet Marshall.
- 4.3. Grow Uniform Spring and Winter Wheat nurseries in Aberdeen
- 4.4. Grow winter and spring wheat stripe rust monitoring nursery in Aberdeen for X. Chen

DURATION: 2019-2025

COOPERATION: Details were integrated in the proposal.

ANTICIPATED BENEFITS/EXPECTED OUTCOMES/INFORMATION TRANSFER:

New cultivars released by this project, combining improved yield with biotic and abiotic resistances, will be grown by wheat farmers and will be used by end-users in Idaho, the PNW, and the US to maintain or increase their productivity and competitiveness in domestic and international markets. Information on cultivars and breeding lines will be distributed to growers through the wheat breeding project website, commodity schools, IGPA meetings and magazines, and publications in Journal of Plant Registration and other journals. QTL and molecular markers identified will be used in the breeding programs worldwide, published in peer refereed journals, and presented at national and international meetings. Students involved in the projects will be trained for work in the public and private sectors after graduation.

LITERATURE REVIEW:

Development of desirable wheat varieties is dependent on the extent of genetic variation, favorable selection environments, and efficient selection methods. Genetic improvement of desirable traits for premier wheat cultivars can be achieved and accelerated by using a combination of traditional and new breeding technologies. Advances in genotyping (SNP, GBS, exome capture, and NGS) are decreasing molecular marker costs and increasing genome coverage to the point that new strategies are now feasible. MAS continues its role in the selection of major genes/QTL, such as resistance to Hessian Fly, dwarf bunt, stripe rust, and favorable glutenin genes. Release of UI Sparrow is an example in using doubled haploid (DH) system in that its release was accelerated by five years compared to the traditional method. Another example from our program is the use of a combination of DH and molecular marker assisted selection. Three hard white spring DH lines (CdDH-266, IDO2002S and IDO2102S) were developed in less than 10 years during mapping of QTL associated with late maturity alpha amylase and cadmium uptake. The two DH lines can be used as parental lines in additional crossing and selection via MAS.

FY2022

IDAHO WHEAT COMMISSION - BUDGET FORM

Principal Investigator: Jianli Chen

If applicable,	Allocated by	Idaho Wheat Commission	during FY 2020	\$159,441
If applicable,	Allocated by	Idaho Wheat Commission	during FY 2021	\$154,305

REQUESTED FY2022 SUPPORT:

Budget Categories	(10) Salaries (staff, post-docs, etc.)	(12) Temp Help	(11) Fringe	(20) Travel	(30) OE	(70) Graduate Tuition/ Fees	TOTALS
Idaho Wheat Commission	\$ 18,720	\$ 69,010	\$ 36,672	\$ 6,000	\$ 26,100	\$ -	\$ 156,502

TOTAL BUDGET REQUEST FOR FY 2022:

\$ 156,502

BREAKDOWN FOR MULTIPLE SUB-BUDGETS:

Budget Categories	Chen	(Insert CO-PI Name)	(Insert CO-PI Name)	(Insert CO-PI Name)
(10) Salaries	\$ 18,720	\$ -	\$ -	\$ -
(12) Temp Help	\$ 69,010	\$ -	\$ -	\$ -
(11) Fringe Benefits	\$ 36,672	\$ -	\$ -	\$ -
(20) Travel	\$ 6,000	\$ -	\$ -	\$ -
(30) Other Expenses	\$ 26,100	\$ -	\$ -	\$ -
(70) Graduate Student Tuition/Fees	\$ -	\$ -	\$ -	\$ -
TOTALS	\$ 156,502	\$ -	\$ -	\$ -

Total Sub-budgets \$ 156,502

Brief Explanatory Comments: (see FY2022 RFP for guidance)

\$18,720 is requested for a senior technician 13 pays salary to do breeding for early generation and MAS.

\$69,010 is requested for six IH working from one month to 16 pays in breeding activities.

\$36,672 is requested to cover benefits for Weidong technician and all his @41.8%

\$6,000 is requested for travels to PNW, growers convention, off-station nurseries.

\$26,100 is requested to cover renting fees of 25 acres field and harvesting bags and stakes, etc

FY2022 Version

ANNUAL REPORT

Grant Code: AP4535
Title: Developing Wheat Cultivars for Idaho
Personnel: J. Chen, J. Wheeler, N. Klassen, W. Zhao, J. Bevan, B. Mangum, J. Prestige, F. Esparza, J. Carrillo
Cooperators: Described below
Address: Dr. Jianli Chen, University of Idaho (UI) Aberdeen Research & Extension Center, Aberdeen, ID 83210; 208-397-4162, ext. 229; jchen@uidaho.edu.

Accomplishments: Promising progress has been made in cultivar development in 2020. Newly released cultivars performed well in production. UI Sparrow produced the highest grain yield in on-farm trials in Soda Springs, Arbon Valley, Rockland, and other locations in Idaho. UI Bronze Jade maintained its improved quality from the reselection last year but also maintained high yield performance. UI Cookie was released in January and a PVP application was filed in July of 2020. It is currently being processed and licensed to Idaho Wheat Commission. We harvested breeder seed for two hard white winter wheat lines IDO1906 and IDO1806. IDO1906 has excellent resistance to both stripe rust and dwarf bunt plus desirable end-use quality. We expect to release it in 2022. Using mix graph data, IDO1806 was reselected for stronger gluten from seeds harvested this summer. We planted IDO1906 and IDO1806 in breeder seed increase plots and two new winter wheat lines, IDO2006 and IDO2008, in breeder seed headrow plots. IDO2006 has better gluten strength in the hard white winter wheat class compared to UI Silver. IDO2008, a new soft white winter wheat line, is earlier than UI Sparrow. Both IDO2006 and IDO2008 have potential to be released in 2022 and grown under both irrigated and dryland production. IDO1906 and IDO2006 were submitted for baking quality testing and will be assessed in the PNW QC in January 2021.

For spring wheat cultivar development, we harvested breeder seeds for two hard white spring lines (IDO1804S and IDO1904S) with stronger gluten than UI Platinum, and two soft white spring wheat lines (IDO1902S and IDO1404S) with better stripe rust resistance than UI Stone. We can release these four lines in 2021 if any interested industry partners are identified. IDO1404S and IDO1902S was assessed in the PNW QC in January 2020 and IDO1804S and IDO1904S will be assessed in the PNW QC in January 2021. We are advancing an additional eight spring wheat lines for breeder seed production in headrow plots in spring 2021. These include four hard white spring wheat lines (IDO2002S, IDO2004S, IDO2102S, and IDO2104HF), two FHB resistant soft white wheats, and two CL plus hard red spring wheats. All new hard white spring wheat lines have improved yield, gluten strength, and stripe rust resistance compared to UI Platinum. IDO2102S has tolerance to late maturity alpha amylase (LMA) and IDO2104HF has resistance to Hessian fly.

Additional novel traits, such as resistant starch and new resistance genes to Hessian fly and FHB, and low PPO were introgressed in the elite backgrounds.

Challenges encountered: A senior technician, Mr. Weidong Zhao, whose salary was paid 50% by this grant left for a new job at the beginning of August. One MS student (Jacob Bevan) graduated in May of 2020 and replaced Mr. Zhao's position. This transition has had some impact on the program because Mr. Bevan has limited breeding experience. One senior postdoc left the program in April and was replaced by a new postdoc with less breeding experience. Although the postdoc was not paid from this project, this transition has had some detrimental effect on the breeding program as well. Senior field technician Natalie Klassen will leave in March in 2021. Her departure will have a significant negative impact on the breeding program.

Projections: 1) Release IDO1708 soft white winter wheat for irrigated production and low Cd end-use products. This line has potential to replace SY Ovation. 2) Release strong gluten hard white spring wheat cultivars (IDO1804S and IDO2002S) with different maturity and value-added traits. 3) Produce breeder seeds for one hard white winter and one soft white winter wheat (IDO2006 and IDO2008), three hard white spring wheats (IDO2004S, IDO2102S, IDO2104HF), two FHB resistant soft white wheats, and two hard red CL PLUS spring wheats. 4) Test new selected lines with resistance to Hessian fly and FHB. 5) Improve grain yield and end-use quality using molecular marker-assisted selection. 6) Deploy new Hessian fly resistance gene *H26* in diverse elite lines in collaboration with Dr. Steve Xu at the USDA-ARS, Fargo, ND.

Publications: (manuscripts in development)

J. Bevan, J. Wheeler, N. Klassen, W. Zhao, R. Wang, and J. Chen. 2021. Comparative QTL mapping of falling number, pre-harvest sprouting, and late maturity alpha amylase in UI Platinum by SY Capstone derived spring wheat population.

L. Qiao, J. Wheeler, N. Klassen, W. Zhao, R. Wang, K. Isham, R. Chowdhury, J. Zheng, J. Chen. 2021. QTL analysis for grain cadmium and related trace metals in a hard white spring wheat population derived from UI Platinum by LCS Star.

J. Chen, J. Wheeler, N. Klassen, W. Zhao, R. Wang, K. O'Brein, J. Marshall, K. Scheorder, and X. Chen. Registration of UI Cookie soft white spring wheat.