

Grant Code: AP6294

Title: Developing Wheat Cultivars for Idaho

Personnel: J. Chen, J. Wheeler, G. Dhillon, J. Pabitra, Y. Gao, F. Esparza, J. Carrillo

Address: Dr. Jianli Chen, University of Idaho Aberdeen Research & Extension Center, Aberdeen, ID 83210; 208-397-4162, ext. 229; jchen@uidaho.edu

Justification/Rationale:

Idaho wheat production contributes significantly to domestic and overseas wheat markets. Nationally, Idaho ranks in the top eight states for wheat production. Idaho hard white production ranks the first in the US and most of wheat production is under irrigated production in the Southeastern Idaho. Hard white (HW) wheat is the newest market class in the USDA wheat classification system as HW wheat has functional qualities that make it desirable to for whole wheat products and blending flour for specific purposes, like tortillas. HW wheat has priced between \$10-\$13+ since January 2022 compared to \$8.45 to \$9.50 for SW wheat. Improved grain yield and end-use quality are the two primary traits required for new wheat cultivars. Resistance to biotic and abiotic stresses contributes greatly to 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 Idaho growers and the wheat industry.

Fusarium head blight (FHB) has emerged in irrigated production areas, especially in spring wheat, due to increasing corn production, no-till practices, and climate change. Dwarf bunt is a critical fungal disease that can constrain the adoption of organic wheat production where chemical seed treatment is not allowed. Other diseases and pests affecting wheat production in Idaho include Hessian fly (HF), barley yellow dwarf virus, bacterial leaf blight, physiological leaf spots, dryland crown rot, cereal cyst nematode, and wireworm. Pre-harvest sprouting and late maturity alpha amylase (LMA/PHS) damage have also become production concerns in recent years. Drought and heat are the main abiotic stresses. In 2021, the Idaho wheat crop suffered record drought and heat stress. 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.

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 generating doubled haploid (DH) lines, using molecular marker-assisted and genomic selection, 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 long-term research goal of the project is to facilitate food safety and security by generating new wheat cultivars that have high grain yield, desirable end-use quality, and resistance to major biotic and abiotic stresses using a combination of traditional and genomics-assisted breeding methods.

Methods/Plan of Work:

- 1. Marketing and Variety Release.** We will assist in marketing of UI Gold and do intensive evaluation of another hard white spring wheat, IDO2002S, and a hard red spring wheat, IDO2202CL2. This work will be in collaboration with Jared Sparkman (see Sparkman proposal). We will also plant pre- foundation seed and prepare release documents for two soft white spring wheat lines, IDO1902S and IDO1404S, for a private company and an overseas baker who are interested in licensing the two lines. In addition, we will plant pre- foundation seed and seek a licensing partner for hard white winter line IDO2006. A seed dealer event will be organized to market these lines.
- 2. Elite and Breeding Line Evaluation (F6 and beyond).**
 - A. We will focus on evaluating the effect of glutenin gene combinations on end-use quality in hard wheat backgrounds using molecular marker and agronomic performance in multiple field nurseries to develop high yielding lines with excellent gluten strength and complex resistance to multiple diseases. Most of these lines will also be assessed with UAS/drone technology and be used in genomic selection for grain yield using phenotypic and genotypic data generated from the NIFA funded WheatCAP project.
 - B. Breeding effort on dwarf bunt resistant cultivars will be leveraged with funding support from USDA-NIFA AFRI.
 - C. Development of resistant-starch spring wheat is a joint effort under a Research Coalition for High Fiber Wheat in US breeding programs.
 - D. Traits that can be genotyped include grain yield, yield components, resistant starch, , height, vernalization, PPD, flowering, storage protein, and resistance to herbicides, FHB, HF (*H25* and *H26*), dwarf bunt, stem rust (*Sr2*, *Sr39*, *Sr47*), and LMA/PHS. The efficiency of marker assisted selection (MAS) will be compared to that of genomic selection.
- 3. Headrow Evaluation (F5).**

Under collaboration with a USDA scientist, we introgressed a HF resistance gene that has a pleiotrophic effect on yield and drought tolerance in our elite backgrounds of both winter and spring wheat. The developed lines with target marker alleles will be evaluated for yield and drought tolerance in headrow plots in the summer of 2023 and in yield trials in 2024. We will also plant UI Silver EMS-treated headrows and near iso-genic lines derived from basic research in addition to the new F1 and F5 headrows.
- 4. Early Generation Tests (F2, F3, and F4).**

We will focus on evaluation of agronomic traits and resistance to stripe rust, bacteria leaf blight, FHB, and on advancing populations using a modified bulk breeding method.
- 5. 2023 New Crosses.**

We will continue backcrossing FHB resistance gene from synthetic wheat, and *FHB 7* into elite winter and spring wheat lines. Top- or backcrosses will be made for strong gluten and a new HF resistance gene in spring wheat. Top- or backcrosses will be made for yield components in spring wheat. LMA and low Cd traits will be introgressed into more elite line backgrounds. High yielding lines from CIMMYTT will be crossed, top- or backcrosses to elite spring wheat lines.

6. Other Collaborative Research Projects:

- A. Grow the Dryland State Variety Trial for winter wheat in Rockland for Dr. Juliet Marshall.
- B. Grow Western Regional Spring and Winter Wheat nurseries in Aberdeen
- C. Grow winter and spring wheat stripe rust monitoring nursery in Aberdeen for Dr. X. Chen
- D. Assess a CIMMYT spring wheat panel in Aberdeen under collaboration with Dr. Krause at Utah State University.

Duration: 2023-2026

Cooperation/Complementation:

Major breeding activities and operation has been directly supported by Idaho Wheat Commission and University of Idaho Agricultural Experimental Station. Traits and new technologies being used in cultivar development are tightly linked to the production concerns and in the national research priorities and are being supported by USDA-ARS NIFA Wheat CAP and AFRI projects.

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 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 field day events, the wheat breeding project website, commodity schools, IGPA meetings and magazines, and publications in Journal of Plant Registration and other journals. QTL, molecular markers, and new candidate genes 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 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. Development of DH lines can reduce the development time for new cultivars and improve selection efficiency. Release of UI Sparrow is an example in using the DH system in that its release was accelerated by five years compared to the conventional method. Another example from our program is the use of a combination of DH and molecular MAS. Three hard white spring DH lines (CddH-266, IDO2002S, and IDO2102S) were developed in less than 10 years during mapping of QTLs associated with late maturity alpha amylase and cadmium uptake. Advances in genotyping (SNP, GBS, exome capture, and NGS) are decreasing molecular marker costs and increasing genome coverage and thus enabling new strategies. MAS has been useful for pyramiding major-effect genes in crops, but it has been less effective when breeding for minor-effect genes (Kearsey and Farquhar, 1998). Genomic selection (GS) represents a more amenable approach to improve traits with complex genetic architecture. First proposed by Meuwissen et al. (2001) for animal breeding, GS develops genomic estimated breeding values (GEBVs) for breeding lines using genome-wide markers. GS can more effectively capture small-effect loci that would otherwise be overlooked by QTL mapping approaches due to limited power to declare significant marker effects (Heffner et al., 2009). GS has been evaluated in wheat for economically important traits, such as grain yield (Hu

et al., 2019; Lozada et al., 2019; Michel et al., 2019a), end-use quality (Ben-Sadoun et al., 2020; Michel et al., 2018; Hu et al., 2019); FHB resistance (Arruda et al., 2015; Arruda et al., 2016; Herter et al., 2019), snow mold resistance (Lozada et al., 2019), stripe rust resistance (Beukert et al., 2020), and winter hardness and frost tolerance (Michel et al., 2019b).

References:

- Arruda MP, Brown PJ, Lipka AE, Krill AM, Thurber C, Kolb FL (2015) Genomic selection for predicting *Fusarium* head blight resistance in a wheat breeding program. *The Plant Genome* 8.
- Arruda MP, Lipka AE, Brown PJ, Krill AM, Thurber C, Brown-Guedira G, Dong Y, Foresman BJ, Kolb FL (2016) Comparing genomic selection and marker-assisted selection for *Fusarium* head blight resistance in wheat (*Triticum aestivum* L.). *Mol Breed* 36.
- Ben-Sadoun, S., Rincant, R., Auzanneau, J., Oury, F. X., Rolland, B., Heumez, E., et al. (2020). Economical Optimization of a Breeding Scheme by Selective Phenotyping of the Calibration Set in a Multi-Trait Context: Application to Bread Making Quality. *Theor. Appl. Genet.* 133, 2197–2212. doi:10.1007/s00122-020-03590-4.
- Beukert, U., Thorwarth, P., Zhao, Y., Longin, C. F. H., Serfling, A., Ordon, F., et al. (2020). Comparing the Potential of Marker-Assisted Selection and Genomic Prediction for Improving Rust Resistance in Hybrid Wheat. *Front. Plant Sci.* 11,1650. doi:10.3389/fpls.2020.594113.
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- Lozada, DN and Carter, AH (2019) Accuracy of Single and Multi-Trait Genomic Prediction Models for Grain Yield in Us pacific Northwest winter Wheat. *Crop Breeding, Genet. Genomics* 2019, 1. doi:10.20900/cbgg20190012.

FY2024

COMMODITY COMMISSION BUDGET

Principal Investigator: Jianli Chen

Allocated by	Idaho Wheat Commission	during FY2022	\$	156,502
	(Commission/Organization)			
Allocated by	Idaho Wheat Commission	during FY2023	\$	155,960
	(Commission/Organization)			

REQUESTED SUPPORT:		Awarded for FY2023	Requested for FY2024
Budget Categories			
(10) Salary (staff, post-docs, et	NOTE: Faculty salary/fringe not allowed	\$ 36,400	\$ 21,320
(12) Temporary Help/IH		\$ 47,520	\$ 56,000
(11) Fringe Benefits		\$ 34,240	\$ 32,475
(20) Travel		\$ 5,000	\$ 10,000
(30) Other Expenses		\$ 32,800	\$ 47,000
(40) Capital Outlay >\$5k		\$ -	\$ -
(45) Capital Outlay <\$5k		\$ -	\$ -
(70) Graduate Student			
Tuition/Fees		\$ -	\$ -
TOTALS		\$ 155,960	\$ 166,795
TOTAL BUDGET REQUESTED FOR FY2024:			\$ 166,795

BREAKDOWN FOR MULTIPLE INDEXES:				
Budget Categories	(Insert Lead PI name)	(Insert Co-PI Name)	(Insert Co-PI Name)	(Insert Co-PI Name)
(10) Salary (staff, post-docs, et	\$ -	\$ -	\$ -	\$ -
(12) Temporary Help	\$ -	\$ -	\$ -	\$ -
(11) Fringe Benefits	\$ -	\$ -	\$ -	\$ -
(20) Travel	\$ -	\$ -	\$ -	\$ -
(30) Other Expenses	\$ -	\$ -	\$ -	\$ -
(40) Capital Outlay >\$5k	\$ -	\$ -	\$ -	\$ -
(45) Capital Outlay <\$5k	\$ -	\$ -	\$ -	\$ -
(70) Graduate Student				
Tuition/Fees	\$ -	\$ -	\$ -	\$ -
TOTALS	\$ -	\$ -	\$ -	\$ -
Total Sub-budgets				\$ -

Budget Justification	
\$ 21,320	New field technician 50% salary @ \$20.50/hr
\$ 56,000	Senior Research Aide, 9 months full-time @ \$20/hr (\$28,800); 2 seasonal assistants @ \$17/hr (\$27,200)
\$ 32,475	Staff fringe rate for all employees @ 42%
\$ 10,000	\$2000/person for 2 persons to attend PNW QC and the Tristate Growers Convention,
\$ 47,000	\$2000 for travel to off-station nursery.
	30 acres land \$600/acre (\$18,000), rent GH \$500 per month (\$6,000), breeding
	supplies (\$10,000), limited Lab supplies (\$3000), AZ seed increase (\$10,000)

ANNUAL REPORT

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Address: Dr. Jianli Chen, University of Idaho Aberdeen Research & Extension Center, Aberdeen, ID 83210, 208-397-4162, ext.229; jchen@uidaho.edu

Abstract:

The Aberdeen Breeding and Genetics Program led by Dr. Jianli Chen focused on hard white wheat variety development in 2022 and released UI Gold to Idaho growers. UI Gold is a hard white spring wheat with high grain yield and excellent bread-baking quality that potentially could replace cultivars Dayn and SY Teton in Southeastern Idaho in 2024 - 2025 production. The breeding program also produced pre-foundation seed for two hard white spring wheat lines, IDO2104S, IDO2002S, and one soft white spring wheat line, IDO1902S. In addition, we produced a large quantity of breeder seed for hard red spring wheat line IDO2202CL2 which has two resistance genes to Beyond herbicide, and two hard white winter wheat lines, IDO2006S and IDO1906S. All new lines have good baking quality as tested in the GrainKraft Lab in Blackfoot. The breeding program has developed elite lines with high yield and excellent quality combined with resistance to stripe rust, FHB, hessian fly, dwarf bunt, and abiotic stresses. The breeding program also developed 2 KASP markers for selecting grain yield and completed in-house KASP genotyping of ~5,000 lines for multiple traits. These efforts are leveraged with two federal grants from USDA-NIFA for the coming three to five years.

Background/Objectives:

Idaho wheat production contributes significantly to domestic and overseas wheat markets. Nationally, Idaho ranks in the top eight states for wheat production. Idaho hard white production ranks first in the US. Most Southeastern Idaho wheat production is under irrigation. Hard white (HW) wheat is the newest market class in the USDA wheat classification system. HW wheat has functional qualities needed for whole wheat products and for blending flour for specific products such as tortillas. HW wheat has been priced between \$10-\$13+ since January 2022 compared to \$8.45 to \$9.50 for SW wheat. The objectives of the present study in 2022 were to release hard white spring wheat cultivars that have high grain yield, excellent bread-baking quality, and resistance to biotic and abiotic stresses. Also, we sought to use integrated technologies to develop new wheat cultivars of various classes with improved grain yield, excellent end-use quality, and stacked multiple resistance to diseases and insects.

Results/Accomplishments:

The Aberdeen Breeding and Genetics Program focused on hard white wheat variety development in 2022 and released UI Gold hard white spring wheat with high grain yield and excellent bread- baking quality to Idaho growers. This cultivar has the potential to replace cultivars Dayn and SY

Teton in Southeastern Idaho in 2024 - 2025 production. The breeding program also produced pre-foundation seed for hard white spring wheat lines IDO2104S and IDO2002S, and the soft white spring wheat line IDO1902S. In addition, we produced a large quantity breeder seed for the hard red spring wheat line IDO2202CL2 with two resistance genes to Beyond herbicide, and hard white winter wheat lines IDO2006S and IDO1906S. The good baking quality of these lines was verified through testing at the GrainKraft Lab in Blackfoot. In addition to the cultivar releases, the breeding program has developed new elite lines with high yield and excellent quality combined with resistance to stripe rust, FHB, hessian fly, dwarf bunt, and abiotic stresses.

In the early stage of variety development, we introgressed *H26* and *FHB7* in collaboration with USDA-ARS at Fargo, ND. The *H26* gene has pleiotrophic effects on several important economic traits, such as grain yield, drought tolerance, and nutrient use efficiency (note that this is confidential information pending peer-reviewed publication in 2023). *H26* was introgressed into the adapted winter wheat cultivars UI Sparrow and UI Bronze Jade and six adapted spring wheat cultivars or elite lines. Evaluation of these lines will be our focus in 2023. *FHB7* gene sources and new synthetic wheats have been crossed to the lines with *Fhb1* to stack multiple FHB genes.

The breeding program also developed two KASP markers for selecting grain yield and completed in-house KASP genotyping of ~5,000 lines for multiple traits, including grain yield, herbicide resistance, and resistant starch, and genes for glutenin, *Rht*, *PPD*, and vernalization. *Fhb1* and *Fhb7*, *H25* and *H26*, and dwarf and common bunt resistance. These efforts are leveraged with two federal grants from USDA-NIFA. We applied UAS (Drone) technology in a two-acre yield nursery and anticipate using the data for genomic selection in cultivar development. We have successfully established the CRISPr-CAS 9 system and obtained edited plants for two important genes. Our long-term goals are to clone genes controlling grain yield/or yield components and genes for resistance to dwarf and common bunt.

Outreach/Applications/Adoption:

The breeding program hosted a seed dealer event and distributed rack cards and variety descriptions. We had 25 participants from seed and milling companies, growers, and the Idaho Wheat Commission. We also demonstrated potential releases and NIFA projects at two field day events in Aberdeen and Rockland this summer. In addition, we planted seed expansion for UI Gold in Arizona this fall.

What are the deliverables?

New cultivars released by this project, combining improved yield with biotic and abiotic resistances, have been grown by wheat farmers, and 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 have been distributed to growers through field day events, the wheat breeding project website, commodity schools, IGPA meetings and magazines, and publications in the Journal of Plant Registration and other journals. QTL, molecular markers, and new candidate genes 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.

- Next Steps / Projections:**
- Assist with the UI Gold licensing process and release another spring wheat cultivar.
 - Plant breeder seed increase for IDO2202CL2 and IDO1902S.
 - Advance new elite lines with value-added traits assessed via field testing, MAS, and genomic selection.
 - Publish two to three refereed papers in prestigious journals.
 - Make three presentations at the professional meetings. If travel is permitted, give talks at an international meeting in Austria.
 - Attend other professional meetings: PAG, CSSA, Western Wheat Workers, GrainGrower Convention
 - Organize a seed dealer event and conduct two field days at Rockland and Aberdeen and participate in field days organized by others.

Publications / Presentations / Popular articles / News Releases / Variety Releases:

Refereed Publication

Strawn, D.G., [D. Mohotti](#), [E. Carp](#), [X. Liang](#), [J. Chen](#), [K. Schroeder](#), [J. Marshall](#). 2022. [Cadmium concentrations in Idaho wheat grain and soil](#). Agrosyst Geosci Environ. <https://doi.org/10.1002/agg2.20288>. **IF: 4.0**. Contributed research ideas, study materials, and editing of the manuscript.

J. Chen, J. Wheeler, J. M. Marshall, X.M. Chen, S. Windes, M. Su, B. Yimer, K. Schroeder, C. Wilson, C. Jackson. Registration of UI Gold Wheat. Accepted by the Journal of Plant Registration.

Invited talk

Chen, J. 2022. Understanding low falling number wheat using an integrated approach, invited talk by the FN workshop committee. Virtue meeting. Jan. 26, 2022.

Chen, J. 2022. Developing wheat cultivars for Idaho. Oral presentation at WSCIA meeting. Northern Quest Resort & Casino, OR. Nov.14 -15.

Poster Presentation

Chen, J., M. Krause, F. Xiao, T. Gordon, R. Wang, J. Marshall, B. Goates, and D. Hole. 2022. Research progress on dwarf bunt resistance in winter wheat in the Western US. E-Poster. The Second International of Wheat Congress, Beijing, P.R. China. Sep.11-15.

Other presentations

Field day presentation at Aberdeen to seed dealers for seed production, variety development and basic research projects. Provided variety description flyer and marketing materials.