

**Grand Code** AP5483  
**TITLE** Developing Wheat Cultivars for Idaho  
**PERSONNEL** J. Chen, J. Wheeler, E. Funk, M. Su, 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:**

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 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, barley yellow dwarf virus, bacterial leaf blight, physiological leaf spots, dryland crown rot, cereal cyst nematodes, and wireworm. Pre-harvest sprouting and late maturity alpha amylase damage have also become production concerns in recent years. Drought and heat are the main abiotic stresses. In 2021, Idaho growers 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.

**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 Sparrow, UI Bronze Jade, UI Cookie). Release IDO1804S as a strong gluten hard white spring wheat cultivar, for all production areas to replace Dayn. Release IDO2002S for irrigated production to replace UI Platinum. Plant on-farm trials and continue variety trials for HWS lines IDO2104HF and IDO2004S, SWS lines IDO1902S and IDO1404S, and HRS lines IDO2202CL2 and IDO2105S. Four of these six lines have breeder seeds produced and are ready to release once partners are identified.

**1.2. Breeder Seed Production.** Plant breeder seed increase in plots for IDO2006 (HWW), IDO2008 (SWW), and FHB resistant lines IDO2101FHB and IDO2103FHB; in headrow plots for IDO2104HF and IDO2105S.

**1.3. Elite and Breeding Line Evaluation.** Yield trials are conducted as the Elite Yield Trial (EYT), the Preliminary Yield Trial (PYT), and the 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 southeast ID. Lines in the EYT will be evaluated for resistance to stripe rust, dwarf bunt, FHB, stem rust, and Hessian fly. Elite lines will also be genotyped with known functional markers at the ARS genotyping center at WSU and in our molecular 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, bacteria leaf blight, and head blight and advance populations using a modified bulk breeding method.

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

- 2. Identify Drought Tolerant Germplasm via Drone Technology.** Use drone technology in high throughput phenotyping of grain yield and agronomic traits in 288 spring wheat cultivars and lines, and 192 winter wheat lines being grown under irrigated and non-irrigated conditions. Conduct genomic selection for grain yield using collected phenotypic and genotypic data generated from NIFA funded WheatCAP project.
- 3. Develop Dwarf Bunt Resistant Winter Wheat Cultivars.** Around 384 winter wheat cultivars and breeding lines collected from ID, UT, WA, OR, MT, and CSU will be assessed for dwarf bunt resistance in Logan, UT in the summer of 2022. The selected lines will be planted in the fall of 2022 for agronomic performance in Aberdeen, Kimberly, and Rockland, ID in summer 2023. Genomic selection for dwarf bunt will be done using collected bunt data

and genotypic data generated from NIFA funded bunt project.

#### **4. Molecular Marker Assisted Selection**

- 4.1. Traits that can be genotyped include resistance to FHB, Hessian Fly (*H25* and *H26*), dwarf bunt, stem rust (*Sr2*, *Sr39*, *Sr47*), and LMA/PHS, height, vernalization, PPD, baking quality, yield components, and resistant starch.
- 4.2. Lines identified from activities 2 and 3 will be genotyped. The efficiency of marker assisted selection will be compared to that of genomic selection.

#### **5. Other Collaborative Research Projects**

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

**DURATION: 2019-2025**

**COOPERATION:** Omitted because of page limitation.

#### **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 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 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 a doubled haploid (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 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 three DH lines can be used as parental lines in additional crossing and selection via MAS.

**FY2023**  
**COMMODITY COMMISSION BUDGET**  
**Principal Investigator: (Lead insert name)**

|                           |               |      |
|---------------------------|---------------|------|
| Allocated by _____        | during FY2021 | \$ - |
| (Commission/Organization) |               |      |
| Allocated by _____        | during FY2022 | \$ - |
| (Commission/Organization) |               |      |

| <b>REQUESTED SUPPORT:</b>                                                  | <u>Awarded for FY2022</u> | <u>Requested for FY2023</u> |
|----------------------------------------------------------------------------|---------------------------|-----------------------------|
| <b>Budget Categories</b>                                                   |                           |                             |
| (10) Salary (staff, post-docs, et NOTE: Faculty salary/fringe not allowed) | \$ 18,720                 | \$ 36,400                   |
| (12) Temporary Help                                                        | \$ 69,010                 | \$ 47,520                   |
| (11) Fringe Benefits                                                       | \$ 36,672                 | \$ 34,240                   |
| (20) Travel                                                                | \$ 6,000                  | \$ 5,000                    |
| (30) Other Expenses                                                        | \$ 26,100                 | \$ 32,800                   |
| (40) Capital Outlay >\$5k                                                  | \$ -                      | \$ -                        |
| (45) Capital Outlay <\$5k                                                  | \$ -                      | \$ -                        |
| (70) Graduate Student Tuition/Fees                                         | \$ -                      | \$ -                        |
| <b>TOTALS</b>                                                              | <b>\$ 156,502</b>         | <b>\$ 155,960</b>           |

**TOTAL BUDGET REQUESTED FOR FY2023:**

**\$ 155,960**

**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                      | \$ -                  | \$ -                | \$ -                | \$ -                |
| <b>TOTALS</b>                     | <b>\$ -</b>           | <b>\$ -</b>         | <b>\$ -</b>         | <b>\$ -</b>         |
| <b>Total Sub-budgets</b>          |                       |                     |                     | <b>\$ -</b>         |

## ANNUAL REPORT

**Grant Code:** AP5483  
**Title:** Developing Wheat Cultivars for Idaho  
**Personnel:** J. Chen, J. Wheeler, E. Funk, M. Su, P. Joshi, Y. Gao, J. Bevan, J. Prestige, F. Esparza, J. Carrillo  
**Cooperators:** Omitted because of page limitation  
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**Accomplishments:** Significant progress was made in cultivar development in 2021. Newly released cultivar ‘UI Cookie’ was licensed to the Idaho Wheat Commission and performed well under irrigation in multiple environments in Idaho and the PNW. We harvested pre-foundation seed for high yielding line **IDO1804S** and plan its release in spring 2022. This line has consistent high grain yield and excellent baking quality across multiple environments and years. IDO1804S could replace Dayn in both irrigated and dryland production in the PNW. We produced breeder seeds for four hard white spring wheat elite lines IDO2002S, IDO2104HF, IDO2004S, and IDO2102S. These lines all have better bread baking quality than UI Platinum and Dayn. We also produced breeder seeds for soft white spring lines IDO1902S, IDO1702S, and IDO1404S and hard red spring line IDO2202CL2. **IDO2002S** has consistent grain yield, top-notch bread baking quality, and very good resistance to stripe rust. It is adapted to irrigated production and will be released as a replacement for UI Platinum. **IDO2104HF** has good grain yield and desirable baking quality and resistance to hessian fly. **IDO2202CL2** has two herbicide resistance genes, good grain yield and bread-baking quality, and resistance to stripe rust. **IDO1902S** has shown good yield in multiple environments in Idaho, Washington, and Oregon. It also has excellent end-use quality and good resistance to stripe rust. The test weight of **IDO1902S** exceeded that of most soft white cultivars in the trials. Line **IDO1702S** has above average grain yield with high test-weight and excellent resistance to hessian fly. It produced good yield under no-till production in an OSU variety trial in Ione. We can release these lines in 2022 if interested industry partners are identified.

We advanced four spring wheat lines for breeder seed production in headrow plots in spring 2022. These include FHB resistant soft white wheats, IDO2101FHB and IDO2103FHB,) and hard red spring wheats, IDO2105S and JeffersonHF. Novel traits, such as resistant starch and new resistance genes to Hessian fly (*H26*) and FHB (*FHB7*), and low PPO were introgressed in the elite backgrounds.

For winter wheat, we produced breeder seed for two hard white winter lines, IDO1906 and IDO2006, and one soft white winter wheat line, IDO2008. We also advanced 100 elite lines and 520 advanced lines of different market classes, increased seed for 60 doubled haploid lines with multiple dwarf bunt resistance genes, and introgressed novel hessian fly resistance and drought

tolerant materials in elite line backgrounds. More update on winter wheat was included in the progress report for the dwarf bunt grant.

**Challenges encountered:** COVID-19 limited in-person meetings and outreach activities. Field day participation was greatly reduced. Severe drought condition affected dryland wheat production. Natalie Klassen, a senior field technician, left in March. However, a new field technician was not hired until the end of June. This transition did not greatly affect program operations because the senior research technician, Mr. Justin Wheeler, and I helped compensated by putting in extra hours. Despite bad weather and equipment breakdowns occurred several times, harvesting and fall planting went smoothly because the newly hired technician and graduate students provided much-needed extra help.

### **Projections:**

- 1) Release IDO1804S as a strong gluten hard white spring wheat cultivar, for all production areas to replace Dayn. Release IDO2002S for irrigated production to replace UI Platinum.
- 2) Plant on-farm trials and continue variety trials for HWS lines IDO2104HF and IDO2004S, SWS lines IDO1902S and IDO1404S, and HRS lines IDO2202CL2 and IDO2105S. Four of these six lines have breeder seeds produced and are ready to release once partners are identified.
- 3) Plant breeder seed increase in plots for IDO2006 (HWW), IDO2008 (SWW), and FHB resistant lines IDO2101FHB and IDO2103FHB; in headrow plots for IDO2104HF and IDO2105S.
- 4) Use drone technology in high throughput phenotyping of grain yield and agronomic traits in 288 spring wheat cultivars and lines, and 192 winter wheat lines being grown under irrigated and non-irrigated conditions. Conduct genomic selection for grain yield using collected phenotypic and genotypic data generated from NIFA funded WheatCAP project.
- 5) Around 384 winter wheat cultivars and breeding lines collected from ID, UT, WA, OR, MT, and CSU will be assessed for dwarf bunt resistance in Logan, UT in the summer of 2022. The selected lines will be planted in the fall of 2022 for agronomic performance in Aberdeen, Kimberly, and Rockland, ID in summer 2023. Genomic selection for dwarf bunt will be done using collected bunt data and genotypic data generated from NIFA funded bunt project.
- 6) Advance breeding materials that contain a new hessian fly resistance gene and a new FHB resistance gene from wild relatives.
- 7) Select for grain yield, yield components, end-use quality, resistance to diseases and insects using molecular markers.  
Develop more diagnostic molecular markers through fine-mapping and gene-editing approaches through the NIFA funded basic research projects.

### **Publications:**

Isham, K., R. Wang, W. Zhao, J. Wheeler, N. Klassen, E. Akhunov, and J. Chen\*. 2021. QTL mapping for grain yield and three yield components in a population derived from two high-yielding spring wheat cultivars. Theor Appl Genet.

<https://doi.org/10.1007/s00122-021-03806-1>. Conceptualized the study and helped write and revise the manuscript. **IF: 4.4.**

Qiao, L., J. Wheeler, R. Wang, K. Isham, N. Klassen, W. Zhao, R. Chowdhury, J. Zheng, **J. Chen\***. 2021. Novel QTL for grain cadmium content identified in hard white spring wheat. *Frontier in Plant Science*. *Frontier in Plant Science*.  
<https://doi.org/10.3389/fpls.2021.756741>. Conceptualized the study and helped write and revise the manuscript. **IF: 5.8.**

Bevan, B., J. Wheeler, N. Klassen, W. Zhao, R. Chowdhury, 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. Conceptualized the study and helped write and revise the manuscript. In revision.

#### **Oral Presentations:**

**Chen, J.**, 2021. Breeding soft white wheat cultivars with value-added traits, **invited talk** by the US Wheat Associates, Soft White Wheat Quality Summit. Virtue meeting. June 24-25, 2021.

Joshi, P., M. Su, J. Wheeler, and **J. Chen\***. 2021. Genome wide prediction for grain yield, protein content and test weight in common wheat. 2021 International ASA, CSSA, and SSSA. Salt Lake City, UT. Nov. 6 – 10, 2021.

Su, M., L. Qiao, K. Isham, J. Wheeler, K. O'Brein, and **J. Chen\***. 2021. Assessing the effects of four wheat glutenin genes on bread-baking quality. 2021 International ASA, CSSA, and SSSA. Salt Lake City, UT. Nov. 6 – 10, 2021.

**Chen, J.**, R. Chowdhury, D. Hole, M. Krause, T. Gordon. 2021. Assessment of two quantitative trait loci for dwarf bunt resistance in winter wheat grown in Pacific Northwest of the USA. Oral talk. Proceeding of XXI international bunt and smut workshop. Virtue meeting. May 5 – 6, 2021.

**Chen, J.**, D. Hole, M. Krause, T. Gordon., and J. Zhang. 2021. Molecular breeding for resistance to critical bunt diseases in organic wheat production. 2021 International ASA, CSSA, and SSSA. Salt Lake City, UT. Nov. 6 – 10, 2021.