Grant Code: AP4566
Title: Developing Soft White Winter Wheat for Idaho
Personnel: Yueguang Wang, and Randy Lawrence, Department of Plant Sciences, UI.
Collaborator: Jay Kalous, Limagrain Cereal Seeds (LCS)
Address: Yueguang Wang, Department of Plant Sciences, University of Idaho, 875 Perimeter Drive, Moscow, ID 83844-2333; 208-885-9110; ywang@uidaho.edu

Justification/Rationale:
Wheat is one of the world's most important plants. Today, U.S. farmers grow about 50 million acres of wheat, providing food for hundreds of millions of people at home and abroad and supporting jobs in rural communities as well as mills, bakeries, grocery stores and restaurants (https://www.wheatworld.org/wheat-101/). Wheat is the primary grain used in U.S. grain products — approximately three-quarters of all U.S. grain products are made from wheat flour. It is grown in 42 states in the United States. (https://www.wheatworld.org/wheat-101/wheat-facts/). Idaho is one of the few places where buyers can find several different classes of wheat in one place. These classes include soft white (winter and spring), hard red (winter and spring), hard white (winter and spring), and durum. Wheat production plays an important role in Idaho's economy. Idaho wheat production typically averages approximately 100 million bushels/year with a value of almost $500 million (http://www.idahowheat.org/). Wheat production also provides job opportunities, not only in the production process, but also in transportation, storage, milling and input supply industries. The Pacific Northwest (PNW) is the principal soft white winter wheat producing area in the United States. Currently, about 80% of soft white wheat grown in the PNW is sold to international buyers (http://www.idahowheat.org/market/pnw-sww-marketing-plan.aspx). Soft white winter wheat is one of the major agricultural commodities in Idaho. To maintain producer profitability, it is critical to develop new cultivars with high yield potential, good quality and good disease resistance. To achieve these objectives, UI breeding project has used a collaborative approach utilizing an "*Innovative Partnership*" with Limagrain Cereal Seeds (LCS) and individuals from various disciplines incorporating both conventional breeding and newer plant molecular techniques since July 2012. We have successfully released and marketed a series of soft white winter wheat varieties. In 2019, we released two joint conventional varieties – VI Bulldog and VI Frost. In 2020, we released three joint varieties, including one conventional variety – VI Shock, and two Clearfield varieties – VI Voodoo CL+ and VI Presto CL+. With the funding support from IWC, UI wheat breeding program goes well year by year and collaborates very successful with LCS.

Hypothesis & Objectives:
The primary hypothesis of this research is that the recombination of desired genotypes (genes) followed by multi-year, multi-site evaluation in the field and the laboratory will lead to the development of new cultivars of soft white winter wheat with increased yield, improved agronomic characteristics and superior end-use quality, that can be produced with reduced grower input costs. The breeding processes can be accelerated using new technologies. The objective of this project is to develop new soft white winter wheat varieties for PNW and ID.

Procedures/Plan of Work
1. Developing New Soft White Winter Wheat Cultivars:
1.1 Planting locations and materials: Different environmental sites were used to identify the performance. In 2020 fall planting season, five new elite lines UIL15-028024, UIL17-7706 (CL+), UIL13-046145A, UIL13-553051A and UIL13-587007A were selected to attend SVT including

WSU, OSU, UI and WRSWN. UI includes Northern (Kurt Schroeder), Southwestern (Olga Walsh), Southern (Juliet Marshall) and Eastern (Juliet Marshall). A total of 33 elite lines were selected for 2021 Idaho Yield Trials (2021 UI IYT) which were grown in 6 UI locations (Bonners Ferry, Fenn, Cavendish, Lewiston, Genesee, Moscow) and 4 LCS locations (Walla Walla, Reardan, Eureka and Ritzville). A total of 74 advanced breeding lines (F_6 generation) were selected for 2021 UI F_6 yield trials which were planted at 4 UI locations (Moscow, Genesee, Tammany and Ferdinand) and 2 LCS locations (Walla Walla and Reardan). A total of 432 F_5 breeding lines and 160 DH head row selections were planted in Genesee and Walla Walla for first year yield trials. Five grams of each IYT lines, F_6 lines, F_5 lines and DH selections were sent to LCS for molecular marker analysis in the LCS Lab. A total of 640 DH head rows which are from 5 crosses were planted in Moscow. All IYT lines except 3 controls were increased in Genesee and Walla Walla. All F_6 lines were increased in Moscow in order to prepare enough seeds for next year planting. A total of 9,720 F_4 head rows were planted in Moscow for head row selection next year.
A total of 209 F_3 bulk populations were planted in Moscow for head selection next year. A total of 577 F_2 bulk populations were planted in Moscow. Five grams of each F_3 and F_2 populations were sent to LCS and planted in Walla Walla for observation. A total of 678 F_1 crosses were planted in field and greenhouse. Summarizing 2020 fall planting, we planted 3,152 yield plots and 16,744 head rows in UI locations and LCS locations. UI total planting area is 13 acres.

1.2 Breeding methods: The main objective is to develop new varieties. Traditional wheat breeding method is used as primary method. Double haploid and molecular marker assisted selection will also be used to shorten the breeding process. Speed breeding, a new technology, is now being used in the Moscow greenhouse to accelerate the breeding program.

2. Development of CLEARFIELD Soft White Winter Wheat: Three released Clearfield varieties -- UI Magic CL+, UI Castle CL+ and UI Palouse CL+ -- are used as the donors for imazamox resistant genes. UI Magic CL+ is currently the leading 2-gene Clearfield and SWW variety in the PNW with broad adaptation, superior yield potential, excellent test weight and desirable end-use quality. However, UI Magic CL+ is increasingly vulnerable to stripe rust. Its reaction type ranges from MS to S and, as production acreage and rust intensity have both increased, it now requires routine fungicide treatments to avoid yield loss. It is important to rapidly deploy new 2-gene Clearfield varieties with improved rust resistance, high yield potential, and targeted adaptation that will replace UI Magic CL+. In 2020, we released VI Voodoo CL+ and VI Presto CL+ which are from UI Magic CL+ and UI Palouse CL+ separately.

3. Enlarge Germplasm Resources: Backcrossing and top-crossing methods are used to enlarge germplasm resources. Each year, we made more crosses in UI Moscow greenhouse. Besides single crosses, we also made backcrosses, 3-way and 4-way crosses. In 2020, a total of 678 F_1 crosses, including 240 single crosses, 272 3-way crosses and 166 4-way crosses were made in greenhouse.

Duration: 5 years (2022-2026)

Cooperation/Collaboration:

Todd Whitnan	Cooperator	Tammany, ID
Doug Huffman	Cooperator	Cavendish, ID
Darcy Huffman	Cooperator	Fenn, ID
Darrel Ulhorn	Cooperator	Ferdinand, ID
Neil Uptmor	Cooperator	Lewiston, ID
Tim Dillin	Cooperator	Bonners Ferry, ID

Roy Patten	UI Farm Manager	UI-Moscow
Brad Bull	UI Kambitsch Farm	UI-Genesee
Sarah Windes	Cereal Chemist	UI-Aberdeen
Jianli Chen	Wheat Breeder	UI-Aberdeen
Kurtis Schroder	Extension Agronomist	UI-Moscow
Douglas Finkelnburg	Extension Agronomist	UI-Lewiston
Olga Walsh	Extension Agronomist	UI- Parma
Juliet Marshall	Extension Agronomist	UI-Idaho Falls
Xiaming Chen	Mycologist	USDA-ARS Pullman

Anticipated Benefits, Expected Outcomes and Impacts, and Transfer of Information:
The new cultivars and germplasm released by this project will maintain or increase productivity for the wheat producers in Idaho. Yield and end-use quality will be improved, increasing the marketability of Idaho and the PNW wheat, both domestically and internationally. Information on new cultivars will be made available through research publications, extension publications, commodity schools, grower meetings, extension field days and websites.

Literature Review:
The primary purpose of the SWWW breeding program has been the development of wheat cultivars for the wheat producers of Idaho, that improve both yield potential and end-use quality. Examples of such cultivars are Brundage (Zemetra *et al.*, 1998), Brundage 96 (Zemetra *et al.*, 2003), UI-WSU Huffman (Brown, 2014) and three 2-gene IMI soft white winter wheat varieties, such as UI Magic CL+, UI Castle CL+ and UI Palouse CL+ released by the University of Idaho. "UI Magic CL+ is the most widely grown soft white winter wheat Clearfield in the Pacific Northwest. The top-end yield potential of UI Magic CL+ continues to create an increasing demand for seed each year across the region. With excellent test weight grain and a shorter overall plant height, it's not hard to see why this variety has achieved such a dominant position in such a short amount of time." (https://limagraincerealseeds.com/pacific-northwest/soft-white-winter-wheat-seed/ui-magic-cl/).
In 2019, UI Magic CL+ represented 14 percent of the 2019 winter wheat crop and ranked as the most popular soft white wheat planted in northern Idaho, where two-thirds of the state's winter wheat is grown. Overall, UI Magic ranked third among all winter wheat varieties grown across Idaho, totaling 8 percent. In neighboring Washington, UI Magic ranked first among soft white winter wheats with more than 200,000 acres grown, nearly 16% of the 1.29 million acres planted. In Oregon, UI Magic accounted for 478,000 acres or two thirds of the soft white wheat planted for harvest last year. (https://www.uidaho.edu/cals/news-and-events/newsletters/2020/catching-up-with-cals-2-26?utm_source=University+of+Idaho&utm_campaign=03f78fd39c-CALS-Dean-EMAIL_CAMPAIGN_2019-10-30_1_COPY_01&utm_medium=email&utm_term=0_4153a2eec5-03f78fd39c-87145693)

Citations:

Brown, J. 2014. New wheat honors UI graduate. Lewiston Tribune article. 7, 2014.

Zemetra, R.S., M.L. Lauver, K. O'Brien, T. Koehler, E.J. Souza, S.O. Guy, L. Robertson, and B. Brown. 2003. Registration of 'Brundage 96' wheat. *Crop Sci.* 43: 1884.

Zemetra, R.S., E.J. Souza, M. Lauver, J. Windes, S.O. Guy, B. Brown, L. Robertson, and M. Kruk. 1998. Registration of 'Brundage' wheat. *Crop Sci.* 38:1404.

CURRENT AND PENDING SUPPORT Form:

Name: Yueguang Wang

NAME (List PI/PD #1 First)	SUPPORTING AGENCY AND AGENCY NUMBER	TOTAL $ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITT-ED	TITLE OF PROJECT
Wang, Y., Lawrence, R.	Current: Idaho Wheat Commission	$106,077	7/01/2020-6/30/2021	80	SWW Joint Variety Development for PNW & ID with Limagrain Cereal Seeds
Wang, Y., Lawrence, R.	Pending: Idaho Wheat Commission	$102,755	7/01/2021-6/30/2022	80	SWW Joint Variety Development for PNW & ID with Limagrain Cereal Seeds

IDAHO WHEAT COMMISSION - BUDGET FORM

Principal Investigator: (Yueguang Wang)

If applicable,	**Allocated by**	**Idaho Wheat Commission**	**during FY 2020**	**$ 99,046**
If applicable,	**Allocated by**	**Idaho Wheat Commission**	**during FY 2021**	**$ 106,077**

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	$ -	$ 58,160	$ 4,595	$ 10,000	$ 30,000	$ -	$ 102,755

TOTAL BUDGET REQUEST FOR FY 2022: **$ 102,755**

BREAKDOWN FOR MULTIPLE SUB-BUDGETS:

Budget Categories	*(Insert PI Name)*	*(Insert CO-PI Name)*	*(Insert CO-PI Name)*	*(Insert CO-PI Name)*
(10) Salaries	$ -	$ -	$ -	$ -
(12) Temp Help	$ -	$ -	$ -	$ -
(11) Fringe Benefits	$ -	$ -	$ -	$ -
(20) Travel	$ -	$ -	$ -	$ -
(30) Other Expenses	$ -	$ -	$ -	$ -
(70) Graduate Student Tuition/Fees	$ -	$ -	$ -	$ -
TOTALS	$ -	$ -	$ -	$ -

Total Sub-budgets $ -

Brief Explanatory Comments: (see FY2022 RFP for guidance)

FY2022 Version

Annual Report

Grant Code: AP4566

Title: Developing Soft White Winter Wheat for Idaho

Personnel: Yueguang Wang, and Randy Lawrence, Department of Plant Sciences, UI.
Collaborator: Jay Kalous, Limagrain Cereal Seeds (LCS)

Address: Yueguang Wang, Department of Plant Sciences, University of Idaho, 875 Perimeter Drive, Moscow, ID 83844-2333; 208-885-9110; ywang@uidaho.edu

Accomplishments: The Soft White Winter Wheat (SWWW) project was conducted by UI North Idaho Wheat Breeding Team in cooperation with Limagrain Cereal Seeds (LCS). Significant achievements of the SWWW project over the past year include:

1. Released three joint varieties (VI Shock, VI Voodoo CL+ and VI Presto CL+) in 2020. VI Shock is a traditional variety. It showed high yield potential in irrigated or high rainfall. It has consistently good test weight, excellent stripe rust resistance and excellent end-use quality. Its pedigree is 01-10704A x 99-06202A.
   VI Voodoo CL+ and VI Presto CL+ are 2 Clearfield varieties. VI Voodoo CL+ showed #1 yielding Clearfield (higher than UI Magic CL+) in intermediate to high rainfall. It has excellent stripe rust resistance and excellent end-use quality. Its pedigree is Artdeco x UI Magic CL+.
   VI Presto CL+ showed high yield potential in low rainfall to high rainfall. It has good stripe rust resistance and moderate resistance to Cephalosporium stripe. Its pedigree is UI Palouse CL+ x Norwest Duet.
   Foundation seeds of the three varieties are available in 2020 fall.
2. Sent 150 pounds of VI Voodoo CL+ and VI Presto CL+ and 175 pounds of UI Magic CL+ (as check) to PNW WQC this fall for milling and baking testing. Preliminary results from Aberdeen's Quality Lab showed that the quality of VI Voodoo CL+ and VI Presto CL+ look similar with UI Magic CL+.
3. Sent 300 grams samples of 2020 UI IYT grown in 7 locations from UI and LCS to Aberdeen Wheat Quality Lab for quality testing. The 7 locations include Cavendish, Fenn, Lewiston, Genesee, Moscow, Eureka and Walla Walla.
4. Sent 300 grams samples of 2020 UI F_6 generation grown in 4 locations from UI and LCS to Aberdeen Wheat Quality Lab for quality testing. The 4 locations include Moscow, Genesee, Tammany and Walla Walla.
5. Sent 300 grams samples of 2020 UI F_5 generation grown in Walla Walla from LCS to Aberdeen Wheat Quality Lab for quality testing.
6. 2020 fall planting was finished at the end of October. The materials were planted at 8 UI locations and 4 LCS locations. UI locations include Moscow, Genesee, Lewiston, Tammany, Cavendish, Ferdinand, Fenn and Bonners Ferry. LCS locations include Walla Walla, Reardan, Eureka and Ritzville.

7. A total of 10 elite lines, including 5 releases (UI Magic CL+, VI Frost, VI Shock, VI Voodoo CL+, VI Presto CL+) and 5 new lines (UIL15-028024, UIL17-7706 (CL+), UIL13-046145A, UIL13-553051A, UIL13-587007A) are selected to attend SVT including WSU, OSU, UI and WRSWN. UI includes Northern (Kurt Schroeder), Southwestern (Olga Walsh), Southern (Juliet Marshall) and Eastern (Juliet Marshall).
8. Head rows of UIL15-028024 and UIL17-7706 (CL+) (2000 head rows for each line, 0.48 acre) were planted in Moscow as breeder seeds next year, because they performed well in SVT this year.
9. Head rows of UIL13-056023A, UIL15-115005, and UIL15-083105 (CL+) (400 head rows for each line) were planted in Moscow and Walla Walla as breeder seeds next year, because Industry is interested in these lines.
10. Head rows of UIL13-046145A, UIL13-587007, and UIL13-553051 (400 head rows for each line) were planted in Moscow as pre-breeder seeds next year, because they were selected to attend SVT this year.
11. A total of 33 elite lines were selected for 2021 Idaho Yield Trials (IYT) which were grown in 6 UI locations (Bonners Ferry, Fenn, Cavendish, Lewiston, Genesee, Moscow) and 4 LCS locations (Walla Walla, Reardan, Eureka, Ritzville).
12. A total of 74 advanced breeding lines (F_6 generation) were selected for 2021 UI F_6 yield trials at 4 UI locations (Moscow, Genesee, Tammany and Ferdinand) and 2 LCS locations (Walla Walla and Reardan).
13. All IYT lines except controls were increased in Genesee and Walla Walla. All F_6 lines were increased in Moscow.
14. A total of 432 F_5 breeding lines were planted in Genesee and Walla Walla for first year yield trials.
15. A total of 160 DH head row selections which are from 8 crosses were planted in Genesee and Walla Walla for first year yield trials.
16. Five grams of each IYT lines, F_6 lines, F_5 lines and DH head row selections were sent to LCS for molecular marker analysis in the Limagrain Lab.
17. A total of 9,720 F_4 head rows were planted in Moscow for head row selection next year.
18. A total of 640 head rows which are from 5 crosses were planted in Moscow.
19. A total of 209 F_3 bulk populations were planted in Moscow for head selection next year.
20. A total of 577 F_2 bulk populations were planted in Moscow.
21. Five grams of each F_3 and F_2 populations were sent to LCS and planted in Walla Walla for observation.
22. A total of 678 F_1 crosses, including 240 single crosses, 272 3-way crosses and 166 4-way crosses were planted in field and greenhouse.
23. Summarizing 2020 fall planting, we planted 3,152 yield plots and 16,744 head rows in UI locations and LCS locations. UI total planting area is 13 acres.

Projections: Moscow greenhouse is used to make crosses and increase top cross F_1 and F_2 seeds. Crosses including single crosses, 3-way and 4-way crosses were made during summer. Single crosses are planted in field. 3-way and 4-way crosses are planted in greenhouse. Speed breeding method is being used to shorten generation time. Seeds are germinated in petri dishes with moistened filter paper, then put the dishes into growth chamber for vernalization at constant temperature (36°F) and photoperiod (8 hours light / 16 hours dark) for 2 months. The vernalized seedlings are transplanted into 12x6 cell flats and grown in greenhouse at 22/2 hours (light/dark)

and temperature 75°F/65°F (light/dark). The plants are fertilized continuously. The heads are cut at two weeks after anthesis, dried at 86°F (30°C) for one week. Thresh the dried heads and repeat the steps as above. This makes it possible to cycle through 3 generations per year. Another advantage of speed breeding is that we can plant more crosses one time, e.g., 3600 lines in cells VS 256 lines in pots per bench. Currently, 272 3-way crosses and 166 4-way crosses are growing in the greenhouse.

Double Heploid (DH) is a fast and effective method to shorten breeding process. In 2020, 5 DH lines which came from 2018 crosses were planted in head rows in Moscow for observation and selection. We also will continue to select and send multiple crosses to LCS for DH treatment in the future.

Field management, such as weed and pest control, will be emphasized to help ensure success of field trials. Data will be taken during different growth stages. Early generation selection (F_1, F_2, F_3 and F_4), high generation selection (F_5, F_6, IYT, et al.) and head selection for breeder seeds will be a priority for us next year. When harvested, we will prepare and plant seeds for State Variety Testing Trials, Western Regional and Idaho Yield Trials at different locations in Washington, Oregon and Idaho. Also we will continue to prepare and plant seeds from each generation for ongoing wheat breeding projects.

Publications: No