PROJECT NO: BJKY26

TITLE: Developing Soft White Winter Wheat for Idaho

PERSONNEL: Yueguang Wang, Randy Lawrence, PSES, University of Idaho.
Collaborators: Jay Kalous, Limagrain Cereal Seeds (LCS)

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JUSTIFICATION:
Idaho is one of the few places in the world where buyers can find several different classes of wheat in one place. These classes include soft white wheat (winter and spring), hard red wheat (winter and spring), hard white wheat (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 creates over 8,500 jobs, 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 (SWWW) 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). SWWW 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, the 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.

The proposed project will build on the large SWWW breeding efforts already underway. During 2014 - 2016, 4 SWWW varieties, including UI-WSU-Huffman, UI Castle CL+, UI Magic CL+, and UI Palouse CL+ were released. Over the past year, a total of 13 elite lines (UI-WSU-Huffman, UI Magic CL+, UI Castle CL+, UI Palouse CL+, 01-10704A, 02-29001A, 06-03303B, 07-28017B, 08-00802B, 09-08357A, 09-12453A, 09-15702A, and 09-21102A) were selected for WSU Variety Testing Trials, OSU Variety Testing Trials, UI Variety Testing Trials and Western Regional Trials at different locations in Idaho, Washington and Oregon. A total of 37 elite lines selected for Idaho Yield Trials (IYT) were grown in southern Idaho (Aberdeen), northern Idaho (8 locations) and Washington State (6 locations). A total of 74 advanced breeding lines (F6 generation) were selected for yield trials at 4 locations in Idaho and 2 locations in Washington. A total of 44 F5R breeding lines which came from last year's good F5 lines were planted in Moscow, Genesee, Walla Walla and Reardan for yield trials. The elite lines of F5R, F6 and IYT were sent to Dr. Xianming Chen for stripe rust evaluation. A total of 338 F5 breeding lines were planted in Moscow and Walla Walla for yield trials. A total of 176 Double Haploid (DH) breeding lines were planted in Moscow, Walla Walla for yield trials. A total of 480 DH head rows were planted in Moscow in order to select good lines for next year's yield trial. Five grams of each IYT, F6, F5, F5R and DH line were sent to Walla Walla for molecular marker analysis in the Limagrain Lab. All of the IYT lines except controls were increased in Moscow and Walla Walla. All of the F5R, and F6 lines were increased in Moscow. A total of 7296 SWWW head rows were planted in Moscow for head row

selection next year. A total of 94 F3 SWWW bulk populations were planted in Moscow and Walla Walla for head selection next year. A total of 327 F2 SWWW bulk populations, including 74 3-way populations were planted in Moscow and Walla Walla. Five grams of each F3 and F2 populations were sent to Walla Walla and grown out for observation. A total of 476 F1 crosses, including 376 single F1 crosses and 100 3-way F1 crosses were planted in greenhouse or field. Total of 150 crosses which had less than 5 seeds were planted in greenhouse to produce F2 seeds. Twenty one crosses and excellent varieties were planted in greenhouse to make backcrosses and 3-way crosses. The remaining crosses were planted in field in Moscow. Seven F1 crosses were selected for Double Haploid (DH). The seeds were sent to Limagrain DH Lab.

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 following objectives relate to the identification, recombination, selection, and evaluation of genes, genotypes and breeding lines with the desired characteristics/traits.

1) Develop new soft white winter wheat cultivars with increased yield, improved agronomic traits, abiotic resistance/tolerance, disease resistance, and end-use quality.
2) Improve the level of disease resistance in the soft white winter wheat program's germplasm.
3) Develop and evaluate lines with herbicide resistance to be used as a tool to control grassy weeds in wheat.
4) Initiate collaborations with Dr. Daolin Fu, the new Wheat Molecular Genetics professor who started his work in August 2016.

PROCEDURES:

Breeding Improved New Soft White Winter Wheat Cultivars: Research will be conducted in the greenhouse, field and laboratory in Idaho and Washington according to the collaboration between UI CALS and Limagrain Cereal Seeds (LCS). Each generation planted in Idaho and Washington will be managed by UI and LCS, respectively. Primary research emphasis will be on new cultivar development primarily using traditional wheat breeding methods. Double haploid and molecular marker assisted selection will also be used to shorten the breeding process. New sources of germplasm will be evaluated for traits of interest from programs in the Pacific Northwest and around the world (LCS) and will be collected to make crosses. Crosses between desired genotypes will be made in the greenhouse in Moscow. The F_1 seeds can be planted in the greenhouse and field in Moscow to produce F_2 seeds. Some F_1 seeds from selected crosses can be moved into LCS's double haploid program. Top-crossing and backcrossing will be utilized to transfer specific genes of interest from non-adapted germplasm into Pacific Northwest germplasm. Genotypic screening of top cross and backcross lines will be conducted using molecular markers associated with the desired traits to ensure those lines being advanced carry the genes of interest.

Early generation material (F_2 – F_3) will be evaluated in the field for disease resistance and agronomic traits in Idaho as well as evaluated and managed in Washington by LCS. The F_4 head-row selections will be evaluated in Moscow. Intermediate generation materials (F_5 – F_6) will be evaluated for the same adaptation traits – establishment, heading date, plant height, yield, test weight, grain protein content, flour protein content, flour yield, flour ash, hardness and milling quality, baking quality, and the characterization of starch. F_5 lines will be evaluated in Moscow by

the UI and in Walla Walla by LCS. F_6 lines will be managed and evaluated at four locations in Idaho by the UI and two locations in Washington by LCS. F_5 and F_6 lines will also be evaluated for resistance to stripe rust in inoculated nurseries and Eyespot using a combination of molecular markers. Lines selected for advancement from the F_5 to F_6 generation will be screened for falling numbers scores.

Advanced generation materials (F_7 - F_8) will be evaluated in Idaho Yield Trials (IYT) for stability of these traits across six dryland locations in northern Idaho, two dryland and three irrigated locations in Washington and Oregon, one irrigated location in southern Idaho. The southern Idaho location will be grown and managed in Aberdeen by Dr. Jianli Chen. The locations in Washington and Oregon will be managed by LCS. Stripe rust resistance evaluation will be done on the advanced generation material (F_6 and IYT) in cooperation with Dr. Xianming Chen, USDA-ARS at Pullman, WA. In cooperation with Katherine O'Brien, the F_5 and advanced generation lines will be tested for domestic and foreign end-use quality. Breeding lines that are superior in the advanced trials will be entered into the Western Regional White Winter Wheat Nursery. After two years in the regional trial and prior to cultivar release, superior advanced lines are entered in the Idaho extension trials conducted by Juliet Marshall and Kurtis Schroder. These lines are also tested at this time in extension trials in Washington, Oregon and in private trials conducted by Northwest Grain Growers and Crop Production Services. Prior to release, elite lines are submitted to the Pacific Northwest Wheat Quality Council for end-use quality evaluation. Based on yield performance and quality evaluation, elite lines are then released as cultivars for producers in Idaho and the Pacific Northwest. End-use quality research is in cooperation with Katherine O'Brien. Grain protein, hardness, milling quality, noodle color, solvent retention capacity (SRC) and baking quality of intermediate and advanced lines will be evaluated at the Aberdeen Wheat Quality Laboratory.

Improving Disease Resistance in Soft White Winter Wheat:

Enlarging genetic diversity: Germplasm from many different sources (University of Idaho, Limagrain Cereal seeds, OSU, WSU, etc) will be evaluated for disease resistance and used in crosses to continue to enlarge genetic diversity and introduce new resistance genes. Molecular markers developed within the Limagrain molecular lab are also used to better characterize the resistance genes present in the breeding program, helping to select improved varieties while managing diversity and therefore helping manage the risk of potential major gene breakdown in the program.

Screening for disease resistance: The screening for disease resistance will first be done in the field at various Idaho and Washington locations. This provides a good screening for stripe rust on a regular basis with the opportunity to screen for other potential diseases (e.g., Eyespot) on a more opportunistic basis. Finally, molecular markers will be used to help screen for disease. For disease where resistance is governed by few major genes, molecular markers will be a cheap and high throughput substitute for field screening of Eyespot and WSBMV during early generations. For diseases where several known genes are involved, molecular markers will be used to characterize gene combinations present in each line, as well as to build the gene pyramiding program.

Improving tolerance to abiotic stress: The very large trial network set in place thanks to the collaboration between University of Idaho and Limagrain will help to field screen for abiotic stress resistance (winterkill, and drought mainly). The aim is not to select for extreme environments but more to check that newly released cultivars meet the minimum standards needed by growers and guarantee some level of yield stability.

Development of CLEARFIELD Soft White Winter Wheat: Two-gene imazamox resistant wheat cultivars will be developed with the goal to release adapted herbicide resistant cultivars for use in managing grassy weeds such as jointed goat grass and downy brome. Traditional wheat breeding methodology will be mainly used in this research. Three released Clearfield varieties -- UI Magic CL+, UI Castle CL+ and UI Palouse CL+ -- will be used as the donors for imazamox resistant genes. The materials with desired traits will be selected as parents to make crosses with two-gene resistant lines. Molecular markers for the 2 genes giving resistance to the imizamox have been developed in the Limagrain molecular lab and have been used to characterize existing lines. Therefore, molecular marker assisted selection as well as double haploid will also be used to shorten breeding process.

Cooperation with Dr. Daolin Fu: Dr. Fu is a wheat molecular geneticist. Mutant populations will be studied in his project. For the wheat breeding program, the goals are to improve wheat yield, disease resistance and end-use quality. We can collaborate. For example, the wheat breeding program can provide him research materials, greenhouse and field support. He can provide us new biological techniques and mutants to enlarge wheat genetic diversity.

DURATION: 5 years (2017-2021)

COOPERATION:

Daolin Fu	Wheat Molecular Genetics	UI-Moscow
Katherine O'Brien	Cereal Chemist	UI-Aberdeen
Craig Morris	Cereal Chemist	USDA-ARS Pullman
Kim Campbell	Wheat Breeder	USDA-ARS
Jianli Chen	Wheat Breeder	UI-Aberdeen
Arron Carter	Wheat Breeder	Washington State University
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
Stephen Guy	Extension Agronomist	WSU-Pullman
Michael Flowers	Extension Agronomist	OSU-Corvallis
Roy Patten	Farm Manager	UI-Moscow
Xiaming Chen	Mycologist	USDA-ARS Pullman
Chris Mundt	Mycologist	OSU-Corvallis
Tim Murray	Mycologist	Washington State University
Deven See	Molecular Biologist	USDA-ARS Pullman
Alexander Karasev	Virologist	UI-Moscow
Nilsa Bosque-Pérez	Entomologist	UI-Moscow

ANTICIPATED BENEFITS/EXPECTED OUTCOMES/INFORMATION TRANSFER:
The new cultivars and germplasm released by this project will maintain or increase productivity for the wheat producers in Idaho. End-use quality will be improved, increasing the marketability of Idaho 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, which improve both yield potential and end-use quality. Examples of such cultivars are Brundage (Zemetra *et al.*, 1998), Brundage 96 (Zemetra *et al.*, 2003) and UI-WSU Huffman (Brown, 2014a). UI-WSU Huffman is a joint release, because it resulted from a cross between Bruneau, a cultivar developed by former UI wheat breeder Bob Zemetra, and a wheat breeding line developed at Washington State. This new variety offers "high yields under dryland conditions with excellent quality and good resistance to two important wheat diseases, Cephalosporium stripe and yellow stripe rust" said Jack Brown, University of Idaho plant breeder who oversaw the later development and release of the variety (Brown, 2014b). The breeding program has also emphasized maintaining and improving resistance to diseases that are problems to producers in the Pacific Northwest, specifically stripe rust and *Pseudocercosporella* foot rot. An example of an Idaho SWWW cultivar that was developed with foot rot resistance is 'Simon' (Zemetra et al., 2005). Field selection for resistance to foot rot can be difficult, but the use of the molecular marker for *Pch1* by a collaborative effort of OSU, UI and USDA-ARS scientists (Leonard *et al.*, 2008) has improved efficiency of selection for strawbreaker foot rot resistance.

CITATIONS:

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

Brown, J. 2014 (b). University of Idaho, Dailey Register, 6, 20, 2014.

Leonard, J., C. Watson, A. Carter, J. Hansen, R. Zemetra, D. Santra, K. Campbell, and O. Riera-Lizarazu. 2008. Identification of a candidate gene for the wheat endopeptidase *Ep-D1* locus and two other STS markers linked to the eyespot resistance gene *Pch1*. *TAG* 116: 261-271.

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., T. Koehler, J. Hansen, S.O. Guy, K. O'Brien, L. Robertson, B. Brown and T. Murray. 2003. "Simon" Registration of 'Simon' PVP#2005000001.

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.

IDAHO WHEAT COMMISSION - BUDGET FORM

Allocated by	Idaho Wheat Commission	during FY 2016	$	124,613
Allocated by	Idaho Wheat Commission	during FY 2017	$	86,616

REQUESTED FY2018 SUPPORT:

	Salary	Temporary Help	Fringe	Travel	OE	Graduate Tuition/Fees	TOTALS
Idaho Wheat Commission	$ -	$ 49,600	$ 7,838	$ 8,000	$ 30,000	$ -	$ 95,438

TOTAL BUDGET REQUEST FOR FY 2018: $ 95,438

BREAKDOWN FOR MULTIPLE SUB-BUDGETS:

	(PI name)	*(PI name)*	*(PI name)*	*(PI name)*
Salary	$ -	$ -	$ -	$ -
Temporary Help	$ -	$ -	$ -	$ -
Fringe Benefits	$ -	$ -	$ -	$ -
Travel	$ -	$ -	$ -	$ -
Operating Expenses	$ -	$ -	$ -	$ -
Graduate Student Tuition/Fees	$ -	$ -	$ -	$ -
TOTALS	$ -	$ -	$ -	$ -

Total Sub-budgets $ -

Explanatory Comments: (see FY2018 Guidelines for definition)

11.21.2016 - Version

ANNUAL REPORT

PROJECT NO: BJKY26

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PERSONNEL: Yueguang Wang, and Randy Lawrence, PSES, UI
Collaborator: Jean-Bruno Beaufume, and Jay kalous, Limagrain Cereal Seeds (LCS)

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ACCOMPLISHMENTS

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

1. Produced the four released UI varieties — UI-WSU-Huffman, UI Castle CL+, UI Magic CL+, UI Palouse CL+.
2. Produced breeder seeds of 02-29001A.
3. A total of 13 elite lines (UI-WSU-Huffman, UI Magic CL+, UI Castle CL+, UI Palouse CL+, 01-10704A, 02-29001A, 06-03303B, 07-28017B, 08-00802B, 09-08357A, 09-12453A, 09-15702A, and 09-21102A) were selected for WSU Variety Testing Trials, OSU Variety Testing Trials, UI Variety Testing Trials and Western Regional Trials at different locations in Idaho, Washington and Oregon.
4. A total of 37 elite lines selected for Idaho Yield Trials (IYT) which were grown in South Idaho (Aberdeen), North Idaho (8 locations) and Washington State (6 locations).
5. A total of 74 advanced breeding lines (F_6 generation) were selected for yield trials at 4 locations in Idaho and 2 locations in Washington.
6. A total of 44 F_5R breeding lines which came from last year's good F_5 lines were planted in Moscow, Genesee, Walla Walla and Reardan for yield trials.
7. The elite lines of F_5R, F_6 and IYT were sent to Dr. Xianming Chen for stripe rust evaluation.
8. A total of 338 F_5 breeding lines were planted in Moscow and Walla Walla for yield trials.
9. A total of 176 Double Haploid (DH) breeding lines were planted in Moscow, Walla Walla for yield trials.
10. A total of 480 DH head rows were planted in Moscow in order to select good lines for next year's yield trial.
11. Five grams of each IYT lines, F_6 lines, F_5 lines, F_5R lines and DH lines were sent to Walla Walla for molecular marker analysis in the Limagrain Lab.
12. All of IYT lines except controls were increased in Moscow and Walla Walla. All of F_5R, and F_6 lines were increased in Moscow.
13. A total of 7296 SWWW head rows were planted in Moscow for head row selection next year.
14. A total of 94 F_3 SWWW bulk populations were planted in Moscow and Walla Walla for head selection next year.

15. A total of 327 F_2 SWWW bulk populations, including 74 3-way were planted in Moscow and Walla Walla.
16. Five grams of each F_3 and F_2 populations were sent to Walla Walla and grown out for observation.
17. A total of 476 F_1 crosses, including 376 single F_1 crosses and 100 3-way F_1 crosses were planted in greenhouse or field. Total of 150 crosses which had less than 5 seeds were planted in greenhouse to produce F2 seeds. Twenty one crosses and excellent varieties were planted in greenhouse to make backcrosses and 3-way crosses. The remaining crosses were planted in field in Moscow.
18. Seven (7) F_1 crosses were selected for Double Haploid (DH). The seeds were sent to Limagrain DH Lab.

PROJECTIONS

We planted some of important parents and single crosses in greenhouse in Moscow this year in order to make backcrosses and 3-way crosses in winter. We also want to make more backcrosses and 3-way crosses next summer in order to enlarge UI germplasm for wheat breeding program. Field management, such as weed and pest control, will be emphasized to help ensure success of field trials. Data will be taken during different growing stages. Early generation selection (F_1, F_2, F_3 and F_4), high generation selection (F_5, F_6, 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 Variety Testing Trials, Western Regional and Idaho Yield Trials at different locations in Idaho, Washington and Oregon. Also we will prepare and plant seeds from each generation for ongoing wheat breeding projects.