

PROJECT NO: BJKX26

TITLE: Developing Soft White Winter Wheat for Idaho

PERSONNEL: Yueguang Wang, Randy Lawrence, PSES, University of Idaho.

Collaborators: Jean-Bruno Beaufume, Limagrain Cereal Seeds (LCS)

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JUSTIFICATION:

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 - 2015, 3 IMI varieties, including UI Castle CL+ (09-DH 10), UI Magic CL+ (09-DH 11), UI Palouse CL+ (3-5-10), which include 2-gene resistance to IMI herbicides were released. A total of 9 elite lines (UI-WSU-Huffman, UI Magic, UI Castle, UI Palouse, 01-10704A, 02-29001A, 06-18102A, 06-03303B and 07-28017B) were selected for Variety Testing Trials and Western Regional Trials at different locations in Idaho, Washington and Oregon. A total of 36 elite lines were selected for Idaho Yield Trials (IYT) and they were grown in North Idaho (8 locations), South Idaho (1 location), Washington State (5 locations) and Oregon (1 location). Seventy-two advanced breeding lines (F₆ generation) were selected for yield trials at 4 locations in Idaho and 2 locations in Washington. A total of 796 F₅ breeding lines (656 SWWW lines, 60 DH lines and 80 IMI lines) were planted in Moscow and Walla Walla for yield trials. 7800 head rows (6600 SWWW head rows and 1200 IMI head rows) were planted in Moscow for head row selection in 2016. Also, 120 F₃ bulk populations (83 SWWW populations and 37 IMI populations) were planted in Moscow and Walla Walla for head selection next year. A total of 212 F₂ bulk populations (166 SWWW populations and 46 IMI populations) as well as 794 F₁ crosses (675 single crosses and 119 3-way crosses) were planted in Moscow and Walla Walla for cross selection in 2016.

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 the new Wheat Molecular Genetics professor expected to start 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 will be planted at Idaho State managed by UI and at Washington State managed by LCS. Primary research emphasis will be on new cultivar development. Traditional wheat breeding methods will be mainly used in this research. 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 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, starch quality, starch color, starch molecular structure, noodle color, and baking quality. 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 as Idaho Yield Trial (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, 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 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 select improved varieties while managing diversity and therefore helping manage the risk of potential major gene breakdown on 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 disease (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 disease where several known genes are involved, molecular markers will be used to characterize genes combination present in each line, as well as to build the 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. 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.

Early selection will be used in CLEARFIELD trials. The herbicide Beyond will be sprayed from early generations, such as F₂, F₃ and F₄ to select resistant crosses/lines in Moscow. Intermediate generation materials (F₅ - F₆) and advanced generation material (F₇ -F₈) will be evaluated for the same adaptation traits – yield, test weight, grain protein, herbicide resistance by spraying Beyond. These trials will be conducted in Idaho and Washington year by year. Selected

advanced lines will be entered into Variety Testing Trials and Western Regional Trials at different locations in Idaho, Washington and Oregon with other selected advanced SWWW lines. Prior to release, elite lines are submitted to the Pacific Northwest Wheat Quality Council for evaluation. Based on yield performance and quality evaluation, elite lines are then released as cultivars for producers in Idaho and the Pacific Northwest.

DURATION: 5 years (2017-2021)

COOPERATION:

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 Finkelburg	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 *Pseudocercospora* foot rot. An example of an Idaho SWWW cultivar that was developed with foot rot resistance is 'Simon'. Field selection for resistance to foot rot can be difficult, but the use of the molecular marker for *Pchl* 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 *Pchl*. *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., 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 2015	\$	154,967
Allocated by	Idaho Wheat Commission	during FY 2016	\$	124,613

REQUESTED FY 2016 SUPPORT:

	Salary	Temporary Help	Fringe	Travel	OE	Graduate Tuition/Fees	TOTALS
Idaho Wheat Commission	\$ -	\$ 32,052	\$ 12,564	\$ 10,000	\$ 32,000	\$ -	\$ 86,616

OTHER RESOURCES (not considered cost sharing or match):

TOTAL OTHER RESOURCES \$ -

TOTAL PROJECT ESTIMATE FOR FY 2017:	\$ 86,616 (Requested)	\$ - (Other)	\$ 86,616 (Total)
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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 \$				\$ -

ANNUAL REPORT

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ACCOMPLISHMENTS

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

1. Released 3 IMI varieties — UI Castle CL+ (09-DH 10), UI Magic CL+ (09-DH 11), UI Palouse CL+ (3-5-10), which include 2-gene resistance to IMI herbicides and also showed good performance in yield trials.
2. Produced foundation seeds of UI-WSU-Huffman and 01-10704A.
3. Selected 40 head rows from UI-WSU-Huffman, UI Magic, UI Castle, UI Palouse, 01-10704A, 06-03303B and 06-18102A separately for next year's head rows and breeder seeds. These seeds were kept in UI Parker Farm seed house for future use.
4. A total of 9 elite lines (UI-WSU-Huffman, UI Magic, UI Castle, UI Palouse, 01-10704A, 02-29001A, 06-18102A, 06-03303B and 07-28017B) were selected for Variety Testing Trials and Western Regional Trials at different locations in Idaho, Washington and Oregon.
5. A total of 36 elite lines selected for Idaho Yield Trials (IYT) were grown in South Idaho (Aberdeen), North Idaho (8 locations) and Washington State (6 locations).
6. A total of 72 advanced breeding lines (F_6 generation) were selected for yield trials at 4 locations in Idaho and 2 locations in Washington.
7. The elite lines of F_6 and IYT were sent to Dr. Xianming Chen for stripe rust evaluation.
8. A total of 680 F_5 breeding lines, including 600 SWWW lines and 80 IMI lines were planted in Moscow and Walla Walla for yield trials.
9. A total of 56 F_5R breeding lines which came from last year's good F_5 lines were planted in Moscow, Walla Walla and Reardan for yield trials.
10. A total of 60 Double Haploid (DH) breeding lines were planted in Moscow, Walla Walla and Reardan for yield trials.
11. A total of 101 DH lines with potential IMI resistance were planted in Moscow and Walla Walla.
12. 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.
13. All of IYT lines except controls were increased in Moscow and Walla Walla. All of F_5R , F_5 and F_6 lines were increased in Moscow.
14. A total of 7800 head rows (6600 SWWW head rows and 1200 IMI head rows) were planted in Moscow for head row selection next year.
15. A total of 120 F_3 bulk populations (83 SWWW populations and 37 IMI populations) were planted in Moscow for head selection next year.

16. A total of 212 F₂ bulk populations (166 SWWW populations and 46 IMI populations) were planted in Moscow.
17. Five grams of each F₃ and F₂ populations were sent to Walla Walla and grown out for observation.
18. A total of 42 3-way F₂ populations harvested from Parker Farm's greenhouse were planted in Moscow in head rows and plots. Ten of the 42 3-way F₂ populations were selected for molecular marker assisted selection (MAS) for Rht, Red, Hacc and IMI. Each plant was harvested and five grains were sent to Walla Walla for MAS. The remaining seeds of each plant were planted in head rows in Moscow.
19. The other 32 3-way F₂ populations were harvested in bulk for each population and planted in plots in Moscow.
20. A total of 794 F₁ crosses, including 675 single F₁ crosses and 119 3-way F₁ crosses were planted in greenhouse or field. Seventy five crosses which had less than 5 seeds were planted in greenhouse. The remaining 719 crosses were planted in field in Moscow.
21. Eight F₁ crosses were selected for Double Haploid (DH). The seeds were sent to Limagrain DH Lab.

PROJECTIONS

The important work we did over the past year include:

1. We made more crosses to enlarge germplasm using greenhouse materials and field materials as parents.
2. IMI materials were separated from SWWW in early generation, such as F₂, F₃. This is helpful for selection in early generation by spraying the herbicide Beyond.
3. Molecular marker assisted selection (MAS) was used for 3-way F₂ populations.

We planted some of important parents in field in Moscow this year in order to provide pollens for greenhouse parents during crossing season next year. We hope to increase crosses using both greenhouse and field materials. 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. We also will continue IMI trials including F₂, F₃, F₄, F₅ and yield evaluation and efficacy trial next year. Early generation selection (F₁, F₂, F₃ and F₄), high generation selection (F₅, F₆, 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, and 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.