

PROJECT NO: BJKV32

PERSONNEL: J. Chen, J. Wheeler, N. Klassen, Y. Wang, W. Zhao, B. Bowman, S. Nayak

TITLE: Developing Wheat Cultivars for Idaho and World Markets

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JUSTIFICATION:

Idaho wheat production contributes significantly to domestic and overseas wheat markets. Nationally, Idaho ranks in the top eight states for wheat and wheat product exports. In 2013, Idaho wheat growers harvested around 1.23 million acres of wheat, of which 59% was winter and 41% spring wheat (www.idahowheat.org). Most spring wheat production is in the southern part of the state and is grown under irrigation. Recently, spring wheat lost some acreage to malt barley and corn in this area. Fusarium head blight (FHB) is emerging as a threatening disease, especially for spring wheat, due to increasing corn production, no-till practices, and the recent trends in global climate change. Stripe rust has been the most important disease for both winter and spring wheat as it caused significant yield loss for growers and quality reduction for the wheat industry in 2005, 2011, and 2013. The predominant spring wheat (Alturas, Louise, and Jefferson) and winter wheat (Stephen and Brundage) cultivars are being replaced by the increasing number of new wheat varieties that have better yield, better more genetically complex disease resistance, and desirable end-use quality. In dryland production areas of southern Idaho, snow mold and dwarf bunt are endemic diseases that limit use of winter wheat varieties. Other diseases and pests affecting wheat production in this region include bacterial leaf blight, physiological leaf spots, dryland crown rot, cereal cyst nematodes, and Hessian fly.

Hard white wheat, the newest class of wheat marketed in the U.S., has a high demand in both domestic and export markets to produce whole grain end-use products. Hard white wheat production in Idaho ranked first in 2012 in the US. Its acreage proportion within the state has increased from 4.3% in 2006 to 10% in 2012 because of favorable growing environments. Idaho, especially in southeast Idaho, has well-developed irrigation systems that can be used to manage protein content for high quality hard white wheat. Idaho also has less damage from Fusarium head blight and pre-harvesting sprouting compared to other hard white producing states. Expanding hard white production would help the Idaho economy by helping growers increase their income. The UI Aberdeen wheat breeding program has spent 50% of its effort on hard white cultivar development in the past six years and released two cultivars, UI Silver and UICF Grace, for dryland production in 2009. However, the development of hard white winter wheat for irrigated production has been significantly hindered by undesirable and limited germplasm. To accelerate hard white wheat cultivar releases it is essential to explore new germplasm and to deploy new technology, such as di-haploid system and molecular marker-assisted selection (MAS), in the traditional breeding processes.

HYPOTHESIS & OBJECTIVES: The genetic recombination of desired genes can be selected in a favorable environment and stabilized with the proper methods. This breeding process can be accelerated using a combination of conventional breeding and biotechnology-assisted techniques.

Objectives of this study are: 1) To develop desired wheat cultivars via traditional breeding; 2) To accelerate hard white wheat cultivar development via di-haploid system and MAS; 3) To identify and validate QTL/markers associated with yield, resistance to stripe rust, and FHB.

PROCEDURES

Parental evaluation, selection, and crossing. Adapted elite lines selected from our breeding program and from the Western Regional trials are the main source of parental lines being used to make elite by elite crosses. New germplasm with high yield and desirable end-use quality, resistance to stripe rust, stem rust, and cereal cyst nematodes have also been used in crossing. Before crossing, major parental lines will be genotyped with molecular markers having known function genes or QTLs. In fall of 2013 we planted 560 winter F1s targeting the hard white class, which were derived from elite x materials from the international nursery, Chinese hard white, and the NSGC. We will plant 650 spring F1s in the spring of 2014, including 50% of the hard white class. All F1s except for elite by elite crosses will be backcrossed or top-crossed to elite parents in the field in the spring of 2014. New spring wheat crosses will be made from elite x materials from LCS and the international nursery. **Our major goal** is to develop desirable wheat cultivars for irrigated production, including hard white winter (HWW), hard white spring (HWS), hard red spring (HRS), and soft white spring (SWS). The major traits are yield, end-use quality, resistance to stripe rust (and stem rust), FHB, LMA (late maturity alpha amylase)/PHS (pre-harvest sprouting), cereal nematodes, Hessian fly, dwarf bunt, and snow mold.

Early generation selection. Each year F2, F3, and F4 are usually planted in non-replicated trials in irrigated and water stress environments in southern Idaho. If resources are available, one set of the three generations will be planted in special disease nurseries (such as stripe rust, nematodes, and FHB). Bulk selection will be applied in F2 and F3 based on agronomic performance and disease resistance. Seed color, test weight, protein content will be assessed after harvesting. Head selection will be applied in the F4 based on agronomic performance and disease resistance. Individual heads will be threshed and separated based on seed color and planted in single headrow plots in the following year. In fall of 2013 we planted 240 winter wheat plots and in 2014 we will plant 734 spring wheat plots of the early generations in two field environments: Aberdeen, ID and Walla Walla, WA in collaboration with LCS for stripe rust screening. Stripe rust infection data will be used to guide selection of plots in Aberdeen before harvesting.

F5 headrows will be planted in Aberdeen and be assessed for plant type and agronomic characteristics and disease resistance when it occurs. After harvesting, test weight, seed color, protein, and flour hardness will be assessed and used in grouping of selected headrows into Observation Yield Trials in the following year. In fall of 2013, we planted 4036 winter wheat headrows. In the spring of 2014, we will plant approximately 15,000 spring wheat headrows. Headrow trials are also used for seed increase of F1, DH lines, and for pre-breeder seed production. In the fall of 2013, we planted 560 headrows for winter F1 and 1,200 headrows for pre-breeder seed production of three winter elite lines. In spring 2014, we will plant 650 headrows for spring F1, 400 headrows of DH lines being harvested in greenhouse, and 1,200 headrows for pre-breeder seed production of three spring elite lines.

Yield trials and line evaluation. Yield trials are defined as Elite Yield Trial (EYT), Preliminary Yield Trial (PYT), and Observation Yield Trial (OYT). OYT is the first year, non-replicated trial that is planted in one or two environments depending on seed availability. PYT is the second

year, replicated yield trial that is usually planted in two or three environments. EYT is the third year, replicated yield trial that is planted in four to seven locations depending on resources and budget.

Lines in the EYT will be evaluated for stripe rust by Dr. X. Chen, dwarf bunt by Dr. David Hole, FHB by us, stem rust by Drs. Yu Jin and J.M. Bonman, snow mold by Drs A. Carter and/or J. Marshall, nematodes by Dr. R. Smiley, Hessian fly by Dr. Bosque-Pérez, and Wheat Streak Mosaic Virus by Dr. M. Flower. These lines will also be genotyped with known functional markers and markers identified in our lab based on data generated by Dr. D. See in the ARS genotyping center at WSU and in our MAS lab. After harvesting, end-use quality of the selected lines in the EYT, PYT, and OYT from multiple locations will be assessed in the Idaho Wheat Quality Lab. Hard white selections will also be tested for whole grain end-use quality at ConAgra Flour Mills under a collaborative agreement. Yield, agronomic, disease and insect resistance, and marker data will be used in selection of lines for crossing and evaluation in the Western Regional Trials in the following year.

In fall of 2013, we planted 4,374 yield plots of winter wheat over two irrigated (Aberdeen and Kimberly), one limited irrigated irrigation (Aberdeen), and two dryland locations (Rockland and Arbon). In spring of 2014, we will plant 6000 yield plots of spring wheat over four irrigated locations (Tetonia, Aberdeen, Kimberly, and Parma) and one dryland location (Soda Springs).

Variety testing, marketing, and seed production. In fall of 2013, we entered 9 lines into the Tri-State Variety Trials; 6 lines into the Western Regional Hard and Soft Winter Wheat Trials; 6 lines into IRT (IYT), and 6 lines into the General Mill Winter Wheat Trials. We will enter 5 to 10 lines into the Western Regional Hard and Soft Spring Wheat Trials in 2014. To facilitate marketing of new releases we have planted 30 winter wheat lines in Strip Trials (Group10) in Aberdeen, Rockland and Arbon in the fall of 2013. We will plant 15 spring wheat lines in strip trials in Aberdeen, Kimberly, Soda Spring, and Parma in the spring of 2014. We will do field days in these locations in the summer of 2014. These strip trials will demonstrate variety performance under grower production practices. Seed harvested from the strip trials will be the pure seed source for Western Regional and State Variety Trials as well as for Industry Quality Analysis. The strip trials will also be used as the source of head selections for Breeders Seed Production in the following year.

In 2014, we are going to produce breeder seed for one hard white winter line IDO1101, one hard white spring wheat line IDO1203S, and one hard red spring line IDO862E, Pre-Breeder Seed for one hard white spring wheat line IDO1202S, one hard white winter line IDO1209DH, two soft white winter lines IDO1004 and IDO1108DH We plan to release IDO694C in the spring of 2014.

OTHER RESEARCH PROJECTS RELATED TO VARIETY DEVELOPMENT:

QTL mapping of yield, resistance to FHB and stripe rust. In our preliminary studies, the newly released soft white spring wheat cultivar 'UI Stone' has high yield performance in both irrigated and non-irrigated conditions (Li et al., 2012) and a high level of type II resistance to FHB (Chen et al., 2012). Another soft white cultivar 'Alturas' has good high temperature adult plant (HTAP) resistance to stripe rust (Souza et al., 2004). One RIL mapping population comprised of 225 lines from a cross between UI Stone and Alturas was developed. We propose to meet three objectives over four years. The first objective is to identify QTL associated with

FHB resistance in UI Stone. The second objective is to identify QTL associated with stripe rust resistance in Alturas. The two objectives will be completed in fall 2014. The last objective is to identify QTL associated with yield in UI Stone. After the first year evaluation of grain yield under irrigation, the second year evaluation of grain yield will be conducted under both irrigated and non-irrigated conditions in 2014. All QTL identified from the two mapping populations will be used in future MAS and genomic selection of yield and resistance to FHB and stripe rust.

Marker-assisted breeding for desirable end-use quality of hard white winter and spring wheat.

The objectives of this study are: 1) to deploy MAS for known desirable glutenin subunits Glu-B1-Bx7oe, Glu-D1-Dx5, Glu-D1-Dy10, Glu-A3, Glu-B3, and Glu-D3; 2) to confirm previously identified QTL for their contributions to bread baking quality; and 3) to identify additional QTL contributing to premier bread baking quality in three winter cultivars (Moreland and UI Silver, and Snowmass) and one spring wheat elite line (IDO694C). We are expecting to develop a glutenin profile combining desirable alleles, glutenin subunits, and new identified QTL to select premier bread baking quality of hard white winter and spring wheat in the future. As a bonus, all populations used in the project are derived from elite by elite crosses and we have a high probability of selecting lines suitable for release at the end of the project.

Hard red winter wheat cultivar 'Moreland' has premier bread baking quality. End-use quality of Moreland must be controlled by additional genetic factors as it contains only glutenin subunits Glu-D1-Dx5 and Glu-D1-Dy10. Hard white elite IDO835 also contains glutenin subunits Glu-D1-Dx5 and Glu-D1-Dy10. However, the baking quality of IDO835 is not as good as that of Moreland. One DH population comprised 156 lines from Moreland x IDO835 was developed. Parents and the DH lines in this population are being genotyped with Glu-A3, B3, and D3. The contribution of the three glutenin subunits to baking quality will be analyzed in 2014. Hard white lines with Moreland quality will be selected. In the following year identification of additional QTL will be conducted if the three glutenin subunits are not the major contributors to the premier quality of Moreland.

The hard white winter cultivar 'UI Silver' has very good bread baking quality when grown in diverse environments and contains desirable glutenin subunits Glu-D1-Dx5, Glu-D1-Dy10, and Glu-A3a. UI Silver also has good yield performance under limited water condition, resistance to stripe rust (HTAP), dwarf bunt, and stem rust (*SrTnp*). The hard white cultivar 'Snowmass' released by Colorado State University has very good bread baking quality and contains several desirable glutenin subunits, such as Glu-A1b (Ax2*), Glu-A3e, Glu-B1a1 (Bx7oe), Glu-B3c, Glu-D1-Dx5, and Glu-D1-Dy10. However, both UI Silver and Snowmass are tall and can sometimes lodge if grown under irrigation. The hard white elite line IDO1101 has high yield, resistance to stripe rust, and the short height desirable for irrigated production. However, IDO1101 has weak gluten strength (short mixing time) and unknown glutenin composition. Using IDO1101 as a recurrent parent, two backcrosses will be made by the winter 2013. The BC1F1s will be genotyped for desirable glutenin subunits Glu-A1b (Ax2*), Glu-A3e, Glu-B1a1 (Bx7oe), Glu-B3c, Glu-D1-Dx5, and Glu-D1-Dy10. The selected BC1F1 plants will be used in DH production in the spring of 2014. The BC1F1 derived DH lines will be genotyped for the same glutenin subunits and simultaneously planted in field in fall of 2014. After harvesting in 2015, grain sample of each DH line will be assessed for end-use quality. The effect of glutenin subunits will be analyzed based on quality data from 2015 harvest. In 2015 – 2016, all DH lines will be planted with replications in one irrigated and one rainfed environment. The effect of the

glutenin subunits will be analyzed again using quality data derived from three trials over two years. Desirable hard white DH lines will be determined based on yield, marker genotype, and baking quality over two years. Selected lines will be evaluated in regional trials in 2016-2017 and 2018-2019.

Hard white spring line IDO694C has excellent baking quality and contains Glu-D1-Dx5, Glu-D1-Dy10, Glu-A3a, and QTL1A. Hard white spring cultivar SY Capstone has short mixing time but high yield and high tillering potential. Both IDO694C and SY Capstone have good resistance to stripe rust. In FY14 we obtained 115 DH lines from the cross IDO694C x SY Capstone using HPI service. The DH lines are currently being genotyped for the known glutenin and QTL1A and will be planted in headrow plots in spring of the 2014.

DURATION: five years (2013-2018)

COOPERATION:

University of Idaho: J. Brown, D. Finkelnburg, C. Schroeder, J. Marshall, A. Rashed, M. Thornton, K. O'Brien, N. Bosque-Perez, A. Paszczynski, P. McDaniel, D. Strawn, J. Kuhl. A. Moore

USDA-ARS: J. Bonman, G. Hu, X. Chen, D. Angle, K. Campbell, D. See, S. Xu, J. Yue, et., al
OSU: R. Zemetra, A. Ross, M. Power, R. Smiley; WSU: S. Guy, A. Carter, M. Pumphrey
U.C. Davis: Jorge Dubcovsky, Lee Jackson; Montana State University: L. Talbert, J. Herman
USU: D. Hole; CSU: S. Haley, P. Byrne; Growers: H. Hayden, G. Hoffmeister, et al
General Mills: B. Wilkin; Pendleton Flour Mills: R. McLean; WestBred: D. Clark; LimaGrain: J. Peterson; Heartland Innovations: Ch. Chu; ConAgra Mill: G. Weaver; Syngenta: J. Moffatt

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 growers and be 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, news releases, and publications in Journal of Plant Registration and other journals.

LITERATURE REVIEW

Development of desirable wheat varieties is dependent on the extent of 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 marker-assisted breeding methodologies (Varshney et al., 2006).

In addition to grain yield, improvement of bread baking quality is a vital breeding aim for hard wheat, but its measurement in early generation material is technically demanding. As a result, a number of predictive indirect assays have been developed and widely used to evaluate processing quality, including sodium dodecyl sulfate sedimentation volume (SDS-SED), grain protein content (GPC), grain hardness (GHD), and various mixograph parameters. The end-use quality is determined by a combination of genetic factors and the growing environment of the crop (Rousset et al. 1992; Peterson et al. 1998). A major contributor to the genetic determination of bread making quality is the allelic variants at the loci encoding the high-molecular-weight glutenin subunits (HMW-GS) (Payne et al. 1984), low-molecular weight GS (LMW-GS) and

gliadins (Payne et al. 1987). The gluten fraction as a whole can account for up to one-third of the variation in bread-making quality (Oury et al. 2010). This leaves more than half of the genetic determination of the end-use quality in wheat as yet undefined. Therefore, it is important to identify additional quantitative trait loci that complement the known gluten genes to achieve improved and consistent bread baking quality.

Marker-assisted breeding is vital to developing efficient breeding strategies (Brevis et al., 2010). Advances in genotyping are decreasing molecular marker costs and increasing genome coverage to the point that new strategies are now feasible. To facilitate marker-based breeding in the small grains, the USDA-ARS has established four regional genotyping centers in Manhattan, KS; Pullman, WA; Fargo, ND; and Raleigh, NC. The integration of the genotyping laboratories in the previous CAP projects provides the foundation for the breeding programs to implement marker-assisted selection (MAS) and genomic selection (GS) strategies. MAS combining with DH production will accelerate breeding cycles significantly

References:

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COMMODITY COMMISSION BUDGET FORM

Allocated by	Idaho Wheat Commission	during FY 2013	\$ 138,134
Allocated by	Idaho Wheat Commission	during FY 2014	\$ 240,665

REQUESTED FY 2015 SUPPORT:

	Salary*	Temporary Help**	Fringe ***	Travel****	OE*****	CO	Grad Fees	TOTALS
Idaho Wheat Commission	\$ 34,840	\$ 44,754	\$ 31,660	\$ 15,000	\$ 40,000	\$ -	\$ -	\$ 166,254

OTHER RESOURCES (not considered cost sharing or match):

a) Industry	\$ 7,500
b) UI (salaries, operating)	\$ 109,614
c) Other (local, state)	\$ -
d) USDA-TCAP (Jul-Dec)	\$ 50,000
e) USDA-ATCA (Jul-Dec)	\$ 26,000
f) USDA-NNF (Jul-Dec)	\$ -
TOTAL OTHER RESOURCES	\$ 193,114

TOTAL PROJECT ESTIMATE FOR FY 2015:	\$ 166,254 <i>(Requested)</i>	\$ 193,114 <i>(Other)</i>	\$ 359,368 <i>(Total)</i>
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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	\$ -	\$ -	\$ -	\$ -
Capital Outlay	\$ -	\$ -	\$ -	\$ -
Graduate Student Fees	\$ -	\$ -	\$ -	\$ -
TOTALS	\$ -	\$ -	\$ -	\$ -
Total Sub-budgets				\$ -

Budget:

- * \$34,840 is requested to cover 50% of two staff member's salary for 26 pay periods.
- ** Wage for four summer help working for 6 month, Lyona for one month, and two college student working for four months.
- *** Benefit for all staff, TH, and student based on suggested rates.\
- **** Attend PNW QC and growers conferences and travel to field nurseries.
- ***** Budget for land charges, maintenance and rental of transportation vehicles, rental of greenhouse, purchase field supplies

CURRENT AND PENDING SUPPORT Form:

Name: Jianli Chen

NAME (List PI/PD #1 First)	SUPPORTING AGENCY AND AGENCY NUMBER	TOTAL \$ AMOUNT	EFFECTIVE AND EXPIRATION DATES	% OF TIME COMMITT- ED	TITLE OF PROJECT
	Current:				
J. Chen	Idaho Wheat Commission	\$240,665	7/1/13 – 6/30/14	20	Developing wheat cultivars for Idaho and world markets
J. Chen, J. Marshall	Idaho Wheat Commission	\$44,973	7/1/13 – 6/30/14	5	Digging the genetic factors underlying late maturity α -amylase (LMA) in wheat
J. Chen	USDA-ARS	\$262,620	2/1/2011 – 12/31/2015	5	Phenotyping of NSGC via TACA under T- CAP
Dubcovsky, Chen et al.	USDA-NIFA TCAP	\$510,492 subcon- tracted from 25M	2/1/2011 – 12/31/2015	10	Improving barley and wheat germplasm for changing environments
R. Zemetra, J. Chen, & D. Hole	USDA-NIFA, NNF	\$80,000 subcon- tracted from \$249,000	1/1/11 – 12/31/14	10	Developing the Next Generation of Neoclassical Plant Breeders
J. Chen	BASF	\$15,000	1/1/13 – 12/31/13	5	Development of Imazamox resistant winter cultivars
J. Chen	Idaho Wheat Commission	\$12,888	7/1/13 – 6/30/14	1	Endowment Fund
	Pending:				
J. Chen	Idaho Wheat Commission	\$166,254	7/1/14 – 6/30/15	20	Developing wheat cultivars for Idaho and world markets
J. Chen, J. Marshall	Idaho Wheat Commission	\$56,725 subcon- tracted from \$64,205	7/1/14 – 6/30/15	5	Digging the genetic factors underlying late maturity α -amylase (LMA) in wheat

D. Strawn, J. Chen, P. McDaniel, J. Marshall	Idaho Wheat Commission	\$9,973 subcontracted from \$73,907	7/1/14 – 6/30/15	5	Field-based study of factors affecting cadmium uptake by wheat from Idaho soils
J. Chen	BASF	\$15,000	1/1/14 – 12/31/14	5	Development of Imazamox resistant winter cultivars
J. Chen	Idaho Wheat Commission	\$66,000	7/1/14 – 6/30/15	1	Combine weighing system upgrade
J. Chen	Idaho Wheat Commission	\$12,888	7/1/14 – 6/30/15	1	Endowment Fund

INTERNAL PEER REVIEW/PRINCIPAL INVESTIGATOR VERIFICATION FORM

INTERNAL PEER REVIEW VERIFICATION

Commodity commissions/organizations require internal peer review by colleagues familiar with the subject matter. This proposal has been peer reviewed by the following individuals:

Reviewer 1: J. M. Benman JMB 1/6/14
(Type/Print name) (Signature) (Date)

Reviewer 2: Katherine O'Brien Katherine O'Brien 1/6/14
(Type/Print name) (Signature) (Date)

Dept. Head/ PAUL McDANIEL Paul McDaniel 1/8/14
Unit Administrator (Type/Print name) (Signature) (Date)

PROGRESS REPORT

PROJECT NO: BJKV32

TITLE: Developing Wheat Cultivars for Idaho and World Markets

PERSONNEL: J. Chen, J. Wheeler, N. Klassen, Y. Wang, W. Zhao, B. Bowman, S. Nayak

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

ACCOMPLISHMENT:

In 2013, we evaluated a total of 18,862 yield plots from 31 spring wheat and 22 winter wheat trials over four winter and four spring wheat locations, which accounted for 70% of breeding materials, 20% of TCAP, 5% of mapping, and 5% of LCS (Lima Grain Cereal Seeds) materials. We also evaluated a total of 20,089 headrows over two environments in Aberdeen, which accounted for 65% of breeding, 10% of mapping, 10% of DH (dihaploid or doubled haploid), and 15% of breeder seed.

We filed a PVP invention disclosure for UI Stone soft white spring wheat cultivar released in 2012. The exclusive license of UI Stone was signed with Lima Grain Cereal Seeds (LCS) to market this cultivar in Idaho and some areas in PNW. I have established a joint quality testing program with ConAgra Flour Mills (CFM) and General Mills (GM) for marketing hard white wheat cultivars. Out of over 100 elite hard white spring and winter lines tested CFM and GM are interested in UI Silver and new experimental lines (IDO694C, IDO1202S, and IDO1203S). General Mills purchased and planted all foundation seed of UI Silver harvested this summer and is going to market it with ConAgra Mills in 2014. We produced breeder seed for IDO694C (HWS), pre-breeder seed for M12013 (HWS), IDO1203S (HWS), IDO862E (HRS), and IDO1101 (HWW), selected heads for pre-breeder seed production for IDO1202S (HWS), IDO1004 (SWW), IDO1108DH (SWW), and IDO1209DH (HWW).

Elite lines being close to release were evaluated in variety trials in multiple states in collaboration with breeding and extension programs at U of I, Washington State University (WSU), Oregon State University (OSU), Utah State University (USU), and Colorado State University (CSU). At the same time, all elite lines were evaluated in the USDA-ARS, Stripe Rust Nurseries in Pullman, WA and Dwarf Bunt Nursery in Logan, UT. Some of elite lines were evaluated for resistance to stem rust in Cereal Disease Lab in U of M and in Kenya field nursery, resistance to snow mold in WSU, resistance to Nematodes and virus disease atin OSU, and for Hessian fly resistance in lab at Moscow. Under collaboration with the breeder Jean-Bruno Beaufume at LCS, in Walla Walla and Dr. Xianming Chen at USDA-ARS, Pullman, WA, we had our breeding materials screened for resistance to stripe rust from early generations to elite lines. This allowed discarding to discard susceptible materials more efficiently than before. The selected materials in early generations included the new germplasm from NSGC and the international nurseries and EMS-induced mutation lines. These lines will enrich the current

germplasm pool and accelerate the development of high yielding lines in our program in the future.

Additional progresses:

Di-haploid Production and Testing

We have successfully integrated dihaploid (DH) system in the breeding program. The soft white winter line IDO1108DH and the hard white winter line IDO1209DH were developed using wheat by maize DH system in 2008. The two DH lines have showed very good performance in regional trials in the previous two years. The IDO1108DH is being evaluated in PNW QC. We also advanced 80DH lines from IDO835 x Moreland (ID8M) out of 148 lines evaluated. Twenty of the 80 lines are hard white with good baking quality. In addition, we obtained 140 DH lines from a cross UI Silver x Shaanmai89150, 115 lines from a cross IDO694C x SY Capstone using HPI service to speed up hard white releases for irrigated production.

For 2014, we have planted pre-breeder seed for IDO1108DH and IDO1209DH. The advanced lines (80) from ID8M population have been planted in a replicated yield trial in Aberdeen, in stripe rust trials in Walla Walla and Pullman, WA, in a Dwarf bunt trial in Logan, UT. The seeds of the DH lines from the other two populations are being increased in the greenhouse and will be evaluated for bread baking quality using markers associated with GluD1, GluA3, and GluB3 and will be planted in Aberdeen in fall of 2014. We are expecting to obtain desirable hard white winter DH lines with desirable agronomic traits and good resistance to stripe rust from Moreland x IDO835 in 2014 and from UI Silver x Shaan89150 and IDO694C x SY Capstone in 2015.

QTL mapping for resistance to fusarium head blight in UI Stone x Alturas mapping population

In 2013, we completed two FHB screenings in greenhouse. We also evaluated yield performance in Aberdeen, and resistance to stripe rust in Pullman, WA. My student, (MS) Santosh Nayak, supported by National Need Fellowship did genotyping for 100 SNP and 50 SSR markers (103,315 data points) in this population. He is currently genotyping of this population with GBS (Genome by sequencing).

In 2014, we are going to conduct the 3rd GH screening of FHB resistance in Aberdeen and the 2nd screening of stripe rust in Pullman to identify genomic regions and QTL associated with resistance to FHB and stripe rust. The MS student Santosh is expecting to complete his thesis project and graduate in May of 2014.

New project: screening lines with lower grain heavy metal content, especially cadmium

This project was initiated this summer after harvest based on the request from a private company ConAgra Flour Mill (CFM). They found high Cd content from grain purchased from some grain elevators in Southern Idaho. After discussion with IWC and CFM we have initiated a screening project for materials harvested from diverse locations in the breeding and extension programs. Based on the very preliminary results from the first set screening we found that there is a

significant genetic and environmental effect on grain Cd content in the tested materials. Therefore, the objectives of this study in 2014 are: 1) Continue the Cd screening for elite lines being harvested in 2014 and paid by CFM; 2) Explore markers developed from Durum offered by UCD program; 3) Identify collaborators to do water and soil test for Cd content; 4) Initiate an integrated project to address Cd issue in FY16.

PROJECTIONS:

1. Assist market launch of UI Stone and suggest release and production of foundation seed for IDO694C.
2. Produce breeder seed for IDO862E, IDO1203S, IDO1101, and pre-breeder seed for IDO862T, IDO1202S, IDO1004, IDO1108DH, and IDO1209DH.
3. Assess hard white winter dihaploid (DH) lines via field testing and marker assisted selection.
4. Evaluate yield performance in multiple locations for mutation lines derived from Alturas, Moreland, and IDO621, and recombinant inbred lines with pyramided resistance for FHB, stripe rust, and Hessian fly.
5. Complete QTL mapping for resistance to Fusarium head blight, yield, falling number in UI Stone x Alturas population and have one MS student finish his thesis and degree program and submit manuscripts being derived from his thesis.
6. Attend PNW Quality Council meeting, US Hard White Board meeting, Great Plain Quality Council meeting, Western Wheat Workers meeting, FHB Forum, ASA meeting, Tri-state Growers Conference, and PAG-TCAP
7. Organize and conduct two field days in Rockland and Arbon and attend field days organized by others.

PUBLICATIONS:

- Chen, J., Hu, G., Ch. Chu, and Y. Wu. 2013. STS markers developed from drought tolerance candidate genes and mapped in two mapping populations and one set of nulli-tetrasomic lines of common wheat (*Triticum aestivum*). Cereal Communication (Accepted).
- Liu, Sh., C.A. Griffey, M.D. Hall, A. L. McKendry, J. Chen, W.S. Brooks, G. Brown-Guedira, D. Van Sanford, D.G. Schmale. 2013. Molecular characterization of field resistance to Fusarium head blight in two US soft red winter wheat cultivars. Theor Appl Genet DOI 10.1007/s00122-013-2149-y
- Zhang, J., J. Chen, Ch. Chu, P. Li, W. Zhao, J. Clayton, J. Wheeler, E. Souza, and R. Zemetra. 2013. Genetic dissection of QTL associated with grain yield in diverse environments. Submitted to Theor Appl Genet.