

PROJECT NO: BJKW32

TITLE: Developing Wheat Cultivars for Idaho and World Markets

PERSONNEL: J. Chen, J. Wheeler, Y. Wang, W. Zhao, J. Zhang, B. Bowman, and S. Nayak

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JUSTIFICATION: Idaho wheat production contributes significantly to domestic and overseas wheat markets. Nationally, Idaho ranks top eight for wheat and wheat product exports. In 2012, Idaho wheat growers harvested around 1 million acres of wheat, in which 61% is winter and 39% is spring wheat (www.idahowheat.org). Most of spring wheat production is in the southern part of the state and grown under irrigation. In 2012, 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 number one disease for both winter and spring wheat that caused significant yield loss for growers and quality reduction for the wheat industry in 2005 and 2011. The predominant spring wheat (Alturas, Louise, WB936, and Jefferson) and winter wheat (Stephen and Brundage) cultivars are possibly replaced by the increasing number of new wheat varieties that have better yield, complex resistance, and desirable end-use quality. In dryland production of southern Idaho, snow mold and dwarf bunt are the two endemic diseases that limit use of winter wheat varieties. Other diseases 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. Hard white wheat production in Idaho ranks the first in 2012 in the US. Its acreage proportion within the state has increased from 4.3% in 2006 to 10% in 2012 (Fig. not presented because of page limitation). The UI Aberdeen wheat breeding program has spent 50% of its effort on hard white cultivar development in the past five years and released two cultivars, UI Silver and UICF Grace, for dryland production in 2009. The potential release of additional hard white wheat cultivars for irrigated production was significantly hindered by the stripe rust epidemic which occurred in 2011. IDO835 hard white winter wheat line was too susceptible to stripe rust and could not be released in the summer of 2011 and release of hard white spring wheat line IDO694 was postponed. Low falling numbers caused by low temperature induced late maturity alpha amylase (LMA), moisture sensitive alpha amylase (MSA), and pre-harvest sprouting may affect our high quality hard white production in the state and the nation. Combining high yield with desirable end-use quality and resistance to prevalent diseases is a big challenge for hard white and all classes of wheat. To accelerate hard white wheat cultivar releases it is essential to integrate doubled haploid (DH) production and molecular marker-assisted selection (MAS) into 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 doubled 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. In order to broaden the genetic diversity within our program, we have evaluated germplasm from International Yield Nursery, translocation lines from China, high yielding lines from LimaGrain Cereals (LCS), landraces from NSGC. The selected germplasm has been used in crossing. New germplasm with resistance to stripe rust, stem rust, and cereal cyst nematodes have also been used in crossing. Major parental lines will be genotyped with molecular markers having known function genes or QTLs before crossing. In fall of 2012 we planted 240 winter F1s and will plant 462 spring F1s in spring of 2013. All F1s except for elite by elite crosses will be backcrossed or top-crossed to elite parents in field in spring of 2013. **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, physiological leaf spot, bacterial leaf blight, LMA/PHS, cereal nematodes, Hessian fly, dwarf bunt, and snow mold.

Early generation selection. Each year F2 (BC1F1 and M2), F3 (BC1F2 and M3), and F4 (BC1F3 and M4) 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 the special disease nurseries (such as stripe rust, nematodes, and FHB). Bulk selection will be applied in F2 (BC1F1 and M2) and F3 (BC1F2 and M3) 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 (BC1F3 and M4) 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 2012 we planted 668 winter wheat plots and will plant 502 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 2012, we planted 960 F5 winter wheat headrows. In the spring of 2013, we will plant approximately 9,000 F5 headrows, 1,200 headrows derived from the mutation populations in the Alturas background, and 1,500 headrows derived from MAS populations.

Headrow trials are also used for seed increase of F1, special germplasm, and DH lines, and for seed purification of elite lines before breeder seed production. In the fall of 2012, we planted 240 headrows for winter F1; 160 headrows for seed increase of 160 landraces with novel resistance to

stripe rust; 1200 for seed increase of 300 DH lines; 800 for applying Beyond herbicide of 200 DH lines; 270 headrows for seed purification of three elite lines; and 341 for routine stripe rust monitory nursery. In spring 2013, we will plant 362 headrows for spring F1 and 1000 headrows for seed purification of three 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. Bonman, snow mold by Drs A. Carter and/or J. Marshall, nematodes by Dr. 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 YET from multiple locations will be assessed in the Idaho Wheat Quality Lab. 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 2012, we planted 2000 yield plots of winter wheat in two irrigated (Aberdeen and Kimberly), one limited irrigated irrigation (Aberdeen), and two dryland locations (Rockland and Arbon). In spring of 2013, we will plant 6000 yield plots of spring wheat in three irrigated locations (Tetonia, Aberdeen, and Kimberly) and one limited irrigation location (Aberdeen). Over 50% of spring wheat lines in yield trials were derived from MAS and EMS-mutation lines. We are expecting to plant two additional locations with spring wheat after a new field technician is hired.

Variety testing, marketing, and seed production. In fall of 2012, we entered 10 lines into the UI State Variety Trials; 10 lines into the Western Regional Hard and Soft Winter Wheat Trials; and 9 lines into the Tri-state Winter Wheat Trials. We will enter 5 to 10 lines into the Western Regional Hard and Soft Spring Wheat Trials in 2013. To facilitate marketing of new releases we have planted 45 winter wheat lines in Strip Trials (Group10) in Aberdeen, Rockland and Arbon in fall of 2012. We will plant 30 spring wheat lines in Strip Trials in Aberdeen and Kimberly in the spring of 2013. We will do field days in these locations in the summer of 2013. 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 2013, we are going to produce Breeder Seed for two hard white spring wheat lines IDO694C and IDO1203S, and one hard red spring wheat line IDO862E. We are expecting to select heads from one hard white winter DH line IDO1209 and one soft white winter DH line IDO1108 to produce Breeder Seed of the two lines in 2014. We are hoping to release these lines from 2013 to 2015..

OTHER RESEARCH PROJECTS RELATED TO VARIETY DEVELOPMENT:

QTL mapping of yield, resistances to FHB, and stripe rust. In our preliminary studies, one newly released soft white spring wheat cultivar 'UI Stone' have 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 250 lines from a cross between UI Stone and Alturas was developed. We propose to meet three objectives over the next four years. The first objective is to identify QTL associated with FHB resistance in UI Stone. One FHB screening was completed using F₄ lines in the greenhouse in spring 2012 and another completed using F₅ lines in winter 2012. This population will be genotyped with SSR and SNP markers in 2013 by a student supported by a National Need Fellowship. QTL associated with FHB resistance in UI Stone will be identified using FHB and marker data, and be compared with the QTL previously published. The second objective is to identify QTL associated with stripe rust resistance in Alturas. This population will be evaluated for stripe rust resistance in collaboration with Dr. X. Chen at USDA-ARS at Pullman, WA in 2013 and 2014. The last objective is to identify QTL associated with yield in UI Stone. In 2013, we will plant this population in a yield trial under irrigation; in 2014 and 2015 the population will be planted under both irrigated and non-irrigated conditions. QTL associated with stripe rust resistance and yield identified from this population will be compared to those identified from RioBlanco x IDO444 winter wheat population, developed under the previous wheat CAP. All QTL identified from the two mapping populations will be used in MAS and genomic selection of yield and resistance to FHB and stripe rust in the future.

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 previous 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, 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, baking quality of IDO835 is not as good as that of Moreland. One DH population comprised 156 lines from Moreland x IDO835 was developed and planted in fall of 2012. Parents and the DH lines in this population will be genotyped with Glu-A3, B3, and D3. Contribution of the three glutenin subunits to baking quality will be analyzed in 2013. Hard white lines with Moreland quality will be selected. Identification of additional QTL will be conducted if the three glutenin subunits are not the major contributors to the premier quality of Moreland in the following year.

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 (SrTmp). 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. Hard white elite line IDO1101 has high yield, resistance to stripe rust, and 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 spring of 2014. The BC1F1 derived DH lines will be genotyped with 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 harvesting. In 2015 – 2016, all DH lines will be planted with replications in one irrigated and one rainfed environments. 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. These lines can 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 (identified from RioBlanco x IDO444 population). 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 of this proposal we plan to produce 200 DH lines from the cross IDO694C x SY Capstone using HPI service (\$30 per line) and conduct genotyping of known glutenin and QTL1A and obtain the first year data for yield and bread baking. We are expecting to enter a few selected lines from this population into regional trials in 2015.

DURATION: five years (2013-2018)

ANTICIPATED BENEFITS/EXPECTED OUTCOMES/INFORMATION TRANSFER:

New cultivars, combining improved yield with biotic and abiotic resistances, released by this project 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 would accelerate breeding cycles significantly.

The chemical ethyl methanesulfonate (EMS) mutagenesis is an economical, genotype-independent method for creating mutants with single-nucleotide changes compared to insertional mutagenesis and transgenic methods (Henikoff and Comai, 2003; Kim et al., 2006). Favorable EMS-mutants can be used in variety improvement such as herbicide resistant mutants (Jander et al., 2003) and functional genomics such as TILLING. Chemical mutagenesis has been widely used in cereal crops, such as barley (Larson et al., 1998) and wheat (Guttieri et al. 2004). Based on a preliminary study of mutagenesis to 'Alturas' wheat, we obtained mutation lines with several kinds of mutant types, such as grain hardness gene changed from soft to hard and height genes changed from tall to short. These examples provide very strong scientific evidence for the potential success using chemical mutagenesis in wheat variety improvement. Hard and short Alturas mutation lines have potential to be released in two to three years to replace acres that are grown soft and tall Alturas.

REFERENCES:

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COMMODITY COMMISSION BUDGET FORM

Allocated by Idaho Wheat Commission during FY 2012 \$ 337,227

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

REQUESTED FY 2014 SUPPORT:

	Salary*	Temporary Help**	Fringe ***	Travel****	OE*****	CO*****	Grad Fees	TOTALS
Idaho Wheat Commission	\$ 34,840	\$ 42,574	\$ 29,761	\$ 15,000	\$ 43,000	\$ 23,750	\$ -	\$ 188,925

OTHER RESOURCES (not considered cost sharing or match):

a) Industry (BASF, July - Dec)	\$ 7,500
b) UI (salaries, operating, July - June)	\$ 109,614
c) USDA-TCAP (July - Dec)	\$ 50,000
d) USDA-ATCA (July - Dec)	\$ 26,000
e) USDA-NNF (July - Dec)	\$ 8,000
TOTAL OTHER RESOURCES	\$ 201,114

TOTAL PROJECT ESTIMATE FOR FY 2014:	\$ 188,925 (Requested)	\$ 201,114 (Other)	\$ 390,039 (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	\$ -	\$ -	\$ -	\$ -
Capital Outlay	\$ -	\$ -	\$ -	\$ -
Graduate Student Fees	\$ -	\$ -	\$ -	\$ -
TOTALS	\$ -	\$ -	\$ -	\$ -
Total Sub-budgets				\$ -

* \$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 (June to Nov), Lyona for one month, and one 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, maintainance and rental of transportation vehicles, rental of greenhouse, purchase field supplies, and DH production

***** Purchase Perten IM9500 Protein Analyzer based on the quote price.

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
J. Chen	Current: IWC	\$138,134	7/01/12- 6/30/13	25	Developing wheat cultivars for Idaho and world markets
J. Chen	IWC	\$102,501	7/01/12- 6/30/13	10	Digging the genetic factors underlying late maturity α -amylase (LMA) in wheat
J. Chen	USDA-ARS	\$262,620	02/01/2011- 12/31/2015	5	Phenotyping of NSGC via ATCA under T- Cap
Dubcovsky, Chen et al.	USDA-NIFA TCAP	\$510,495 subcontrac ted from 25M	02/01/2011- 12/31/2015	10	Improving barley and wheat germplasm for changing environments
J. Chen, R. Zemetra, & D. Hole	USDA-NIFA, NNF	\$80,000 subcontrac ted from \$249,000	01/01/11- 12/31/14	5	Developing the Next Generation of Neoclassical Plant Breeders
J. Chen	BASF	\$15,000	01/01/13- 12/31/12	5	Development of Imazamox resistant winter cultivars
J. Chen	Pending: IWC	\$188,925	7/01/13- 6/30/14	25	Developing wheat cultivars for Idaho and world markets
J. Chen & J. Marshall	IWC	\$44,973	7/01/13- 6/30/14	10	Digging the genetic factors underlying late maturity α -amylase (LMA) in wheat

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. Borman JMBorman 12/18/12
(Type/Print name) (Signature) (Date)

Reviewer 2: Stephen Love SLove 18 Dec 12
(Type/Print name) (Signature) (Date)

Dept. Head/ James B. Johnson James B. Johnson 9 Jan 2013
Unit Administrator (Type/Print name) (Signature) (Date)

CAPITAL OUTLAY REQUEST FORM
IDAHO WHEAT COMMISSION

REQUEST: Inframatic 9500 NIR Grain Analyzer

AMOUNT (IWC): \$23,750 (December quote)
funding)

TOTAL AMOUNT: \$23,750 (for a project with shared

PRIORITY: First

Party Making Request: Jianli Chen

Date of Initial Request: Sep. 27, 2012

Contact: Jianli Chen, 1691 S 2700 W, Aberdeen, ID 83210; 208-397-4162, ext. 229; jchen@uidaho.edu

Date of Current Review: (office use only)

Revised Amount: (office use only)

Date of Approval: (office use only)

Amount Approved: (office use only)

Description, Function or Purpose: (do not include justification here)

This analyzer can simultaneously measure grain protein, moisture, and test weight in one sample. The analyzer can be installed in dusty environments. A grain sample can be smaller than 100 grams, which is very useful for selection in early generations, such as headrows. It also compliments the flour testing equipment in quality lab.

Detailed description was included in attached quote.

Timeline: (for purchase or implementation)

August to October each year: winter wheat processing for planting

November to April each year: spring wheat processing for planting

May to July: additional spring and winter wheat processing for research projects

Collateral Expenses: (Impact on overhead, additional personnel required for operation, training, installation, supplies, operational costs; how these additional expenses will be paid for?)

We can better utilize our workers and supplies through selection based on the test weight, moisture and grain protein obtained from this instrument prior to packaging. Currently we package headrows prior to them going to the lab and we end up discarding more than half the packaged seed based on results from the lab. If this equipment is purchased we will be able to reduce the number of headrows that we need to package and reduce the time spent on packaging.

Shared Funding: (Provide a brief description of the arrangement if funding of the total project will be shared with another party. Attach a copy of documentation validating the understanding of shared funding.)

Not identified.

Ownership: (Who will have ownership of the item, or result, of the capital outlay?)

University of Idaho

Permanent Location of Item or Project:

The Aberdeen R & E Center, Aberdeen, ID 83210

Statement of Justification: (need, time savings, replacement, upgrade, advantages, life of investment)

Protein content and test weight are two critical parameters for selecting hard wheat if it can make desirable end-use products. If the selection can be done in early generations (such as F2 to F4 and headrows), that would significantly improve the efficiency and accuracy in the process of variety development. We usually harvest 10% (2000 to 5000) of selected headrows out of 20,000 to 50,000 planted in both winter and spring wheat. If we have capability to discard 50% of harvested headrows that would save our labor and envelopes to package and save labors in quality lab to process them. The amount of lines that don't have a target protein and test weight can be discarded earlier allowing more precision in early generation selection. This selection process is critical especially when the turnaround time from harvest to planting is short as is the case with winter wheat. We currently depend on data obtain from prepackaged small samples processed by quality lab. The data derived from small sample includes: hardness, whole grain flour protein, and SDS sedimentation. We cannot get a test weight from the small sample because the quality lab equipment does not have that capability. When the quality lab is flooded with a large number of small samples it is difficult to receive timely data to be used in decision making for planting especially with winter wheat. Where headrows provide only a small amount of seed we lose 40g of seed (usually 25-33% of the total available seed when we send them for quality testing), we become limited in our ability to plant the selected headrows in replicated trials or multiple locations due to this loss of seed for quality testing. This instrument would greatly reduce or eliminate the loss of limited seed quantities obtain from headrows.

We currently use a dated NIR grain analyzer. This analyzer can only measure grain protein with a sample size greater than 500 grams, thus it cannot be used in the selection of early generations (such as headrows). The NIR also takes 5 minutes to process one grain sample and regular costly maintenance and specialized calibrations are required at least once a year.

The breeding program also shares a Foss 6500 with the cereals extension program also used for grain protein analysis. However, it is difficult to coordinate when both programs have a large quantity of materials to run on it. Like the dated Protein NIR, the Foss 6500 can only do a sample size greater than 500 grams and it does not have the ability to obtain a test weight. The Foss 6500 is also sensitive to changes in the environment (temperature, humidity, etc). Recently it required some repairs and carried a hefty price of over \$5000 to fix it.

The INT9500 can read moisture which is used in yield calculations from test plots. This is especially important when the harvest master on the combine fails to read moisture levels due to low grain yield during harvesting. The harvest master commonly does not read grain moisture when harvesting dryland trials because not enough grain volume allows the equipment to make a moisture reading. Previously we have used the yield data from the harvest master uncorrected for moisture. A corrected yield using moisture is more accurate to assess true yields in dryland. In summary, the INT9500 NIT grain analyzer would be valuable to the breeding program. It can possibly be a shared from time to time with the cereals extension program and wheat quality lab.

Primary and Secondary Users: (Who will use or benefit from capital outlay? other research programs, department personnel, collaborators, funding partners)

Aberdeen Wheat Breeding Program will significantly benefit the capital outlay.

Any program who collaborate with the breeding program will indirectly benefit from the CO.

BIDS OR QUOTES: (Attach two current, within 6 months of the date of this form, itemized bids or quotes, from contractor, product manufacturer or supplier)

Attached is a quote from Perten Instruments INC. Perten is a world recognized company known for producing grain analyzers. This is the only company that produces this kind of equipment with all three functions.

ADDITIONAL INFORMATION: (Attach additional information useful in the decision making process)

It would be highly beneficial if this equipment could be purchased to be used in winter 2012 and spring 2013 to process 2012 harvested spring wheat for planting in spring 2013.

PROGRESS REPORT

PROJECT NO: BJKW32

TITLE: Developing Wheat Cultivars for Idaho and World Markets

PERSONNEL: Jianli Chen, Project Leader; Justin Wheeler, Support Scientist; Jack Clayton, Ag. Seed Technician (passed away in Oct); YueGuang Wang, Post Doctorate; Weidong Zhao, Lab Technician; Junli Zhang, Ph.D student; Brian Bowman, Ph.D student; Santosh Nayak, MS student

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ACCOMPLISHMENTS: The most important accomplishment this year is the release of UI Stone soft white spring wheat cultivar. This cultivar has high grain yield and consistent end-use quality under rain-fed and irrigated conditions, good resistance and/or tolerance to Fusarium head blight (FHB), stripe rust, and cereal cyst nematodes. Registered seed of UI Stone is available for planting in spring of 2013. In addition, two elite lines IDO694C and IDO862E are expecting to be released in 2013. IDO694C hard white spring wheat is adapted in both irrigated and non-irrigated conditions and has excellent bread baking quality and good resistance to stripe rust. IDO862E hard red spring wheat is adapted in rain-fed condition and has improved yield, early maturity, resistance to stripe rust, and good bread baking quality. To speed the release of hard white winter wheat cultivars, we deployed the wheat by maize doubled haploid (DH) system and marker assisted selection (MAS) to select DH lines with desirable glutenin subunits and QTL associated with desirable end-use quality. In 2012, we advanced six DH lines and planted them in the state-wide yield trials and western regional trials in ID, WA, OR, and CO. Using MAS, we also pyramided genes for resistance to FHB (*Fhb1*), stripe rust (*Yr36*), Hessian fly (*H25*), and the high protein content gene *GpcB1*. Around 30 F6 hard white and red spring lines with the four target genes showed good yield performance and will be advanced and evaluated in multiple environments in 2013. Through this project we trained one post doctorate, one visiting scholar, three graduate and two college students this year. My students and I made four oral and three poster presentations at international and national meetings. We published three papers in peer referred journals this year. Details of the accomplishments are summarized in below sections.

Seed Production: In 2012, we planted 3,200 headrows (400 rows per line) with 90 feet isolation for breeder seed production of three released winter wheat cultivars (UICF Grace, UI Silver, and UI SRG) and for pre-breeder seed production of five spring wheat potential releases (IDO694C, IDO858, IDO671, IDO686, and IDO669). UICF Grace, UI Silver, UI SRG, IDO862, and IDO671 were planted in the field in collaboration with the USDA-ARS barley breeder to save land charges and use barley as the isolation crop. IDO694, IDO694c, and IDO858 were planted at the Tetonia R& E Center. IDO686 and IDO669 were planted in the border areas where we planted the TCAP barley nursery. Plant type, spike color, uniformity, and height were evaluated during the growing season and true to type, uniform headrows were harvested individually. After harvesting seeds from individual headrows for the three winter wheat cultivars (UICF Grace, UI

Silver, and UI SRG) were inspected by experienced personnel in the program. Headrows with sound seeds were combined. The composite seed sample went through a purity test and was planted by the Idaho Foundation Seed Program in the fall of 2012 to produce foundation seed in 2013. The spring wheat headrows of the five new lines are being processed utilizing the same modified seed production system.

IDO694C hard white spring wheat is adapted in both irrigated and non-irrigated conditions and has excellent bread baking quality preferred by industry and good resistance to stripe rust. This line has potential to be released in 2013 and replace SnowCrest in Southern Idaho. Because of late planting and poor fertility in the field in Tetonia, we obtained less breeder seed of IDO694C this year than anticipated. The pre-breeder seed of IDO694C will be planted in Aberdeen to produce pre-foundation seed in 2013. Another hard white spring wheat line IDO1203S showed good yield under both irrigated and non-irrigated conditions, good resistance to stripe rust, and good bread baking quality. Breeder seed headrows (400) will be planted in Aberdeen in 2013. IDO862E (a sister line of IDO862) has improved yield, maturity, stripe rust resistance, and end-use quality equivalent to Jefferson. This line has potential to be released in 2013 in the areas where Jefferson grown.

Variety Development: In 2011-12, our major focus was hard white class. Out of 285 winter elite and advanced lines evaluated, 120 lines were hard white. A total of six elite lines (3 hard white IDO1101, IDO1206, and IDO1207; 3 hard red IDO816, IDO1102, and IDO1103) were planted in UI Extension Yield Trials (EYT), Western Regional Hard Winter trials (WRHW), and Tri-state Yield trials (TYT) in ID, WA, OR, and CO this year. In addition, we evaluated 9,609 yield plots for five classes of winter and spring wheat in four locations (two irrigated and two dryland); evaluated 1,231 segregating populations and 16,160 headrows of both spring and winter wheat at Aberdeen.

To speed the release of hard white winter wheat cultivars, we deployed the wheat by maize hybridization method and produced doubled haploid (DH) lines from hard white by hard white and hard white by soft white crosses in 2008. In 2012, a total of 139 DH lines (88 hard white and 55 soft white) were evaluated for agronomic and end-use quality in replicated trials in Moscow (rainfed), Aberdeen (irrigated), and Rockland (dryland), ID. These DH lines were also evaluated for stripe rust resistance in Moscow and Pullman; for dwarf bunt resistance in Logan, UT; and for stem rust resistance in Minnesota, MN and Kenya, South Africa in collaboration with other scientists. A total of six DH lines (3 hard white IDO1208DH, IDO1209DH, and IDO1210DH; 3 soft white IDO1107DH, IDO1108DH, and IDO1110DH) were planted in the IYT, WRHW, WRSW, and TYT in ID, WA, OR, and CO this year.

In addition to above DH lines produced in our program, we obtained additional two DH populations under an agreement with Heartland Plant Innovations (HPI), Inc. in 2010. One population derived from Moreland x IDO835 was made to develop hard white and hard red winter cultivar and another derived from UICF Lambert Plus x IDO835 was made to develop two-gene herbicide resistant hard white cultivars. After completion of greenhouse seed increases these DH lines were planted in a non-replicated yield trial in Aberdeen in the fall of 2012. Before harvest these lines will be evaluated using molecular markers associated with herbicide resistance, stripe rust resistance, and end-use quality.

In 2009, mutation breeding using EMS-mutagenesis was added to the current breeding program to accelerate the genetic improvement of two widely grown cultivars (Alturas and Moreland) and one elite line, IDO621. Our goals were to select mutation lines with reduced height and Alturas with hard grain; with improved stripe rust resistance in the Moreland background; and with improved protein content and baking quality in the IDO621 background. After three years' development and extensive screening we obtained some mutation lines with the improved traits. In the Alturas background, we selected some lines changed from soft to hard grain but maintaining good resistance to stripe rust. Some of these lines have reduced height, increased tillers, increased spike size and/or kernel size. These lines showed great potential to be released as hard white spring wheat that can grow under irrigation. A few of these lines will be entered into regional trials in 2013. We also selected some lines with improved resistance to stripe rust in the Moreland background and improved protein content in the IDO621 background.

Marker-assisted breeding for resistance to fusarium head blight in wheat: In 2012, we focused on screening one set of F₄ lines (300 derived from 752 F₂). Molecular marker assisted selection in previous years allowed us to pyramid genes for resistance to FHB (*Fhb1*), stripe rust (*Yr36*), Hessian fly (*H25*), and the high protein content gene *GpcB1*. These lines were evaluated for agronomic performance under irrigated and terminal drought environments in Aberdeen. These lines were also evaluated for stripe rust resistance in Pullman, WA; for Hessian fly resistance on the Moscow campus; for FHB resistance in field tests in Aberdeen, and in field tests at the University of Minnesota. A total of 45 spring wheat lines were selected with four target genes. Thirty of the 45 showed good yield performance and will be advanced and evaluated in multiple environments in 2013.

Germplasm Introduction, Evaluation, and Utilization: A total of 530 winter wheat germplasm were collected from an international winter nursery coordinated by CIMMYT and seed-increased in 2009 and planted in a single replicate yield trial in 2010 to 2011. These lines were evaluated for end-use quality after harvest. Some of these lines showed very good stripe rust resistance and stiff straw and were used in crossing in 2011 and 2012. For spring wheat we used 10 adapted lines crossed with 17 stripe rust resistance sources. These crosses will be backcrossed to the adapted parents in spring 2013. In 2012, we also evaluated germplasm from LimaGrain Cereals (LCS) under a collaborative agreement. A total of 40 winter elite and 45 spring wheat elite lines were planted with two replications in two locations at Aberdeen and Kimberly.

In conjunction with the Triticeae CAP project, we evaluated a subset of 123 hard white spring lines for bread baking quality, resistance to FHB, and resistance to LMA and pre-harvest sprouting (PHS). Based on one year data, some lines showed a high level of resistance to FHB and/or resistance to LMA or PHS. Of 540 spring wheat core accessions evaluated in the past two years, about 30 were selected as having good yield performance and/or high water and nitrogen use efficiency (WUE and NUE). These accessions have been used in my breeding program and shared with breeders in the TCAP program. QTL and markers associated with yield, WUE, and NUE are being identified.

PROJECTIONS:

We continue our major focus on the development of hard white spring and winter wheat using a combination of traditional and mutation breeding methods, doubled haploid system and molecular marker-assisted selection. Specific goals are: 1) release hard white spring line IDO494C and/or hard red spring line IDO862E; 2) produce pre-foundation seed for IDO694C; 3) produce breeder seed for IDO862E, hard white winter DH line IDO1209, and soft white winter DH line IDO1108; 4) conduct QTL mapping for high grain yield and FHB resistance in UI Stone, stripe rust resistance in Alturas, desirable end-use quality in Moreland; 5) produce additional DH populations and develop glutenin profile for premier bread baking quality in hard white wheat cultivars UI Silver, Snowmass, and IDO694C.

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