PROJECT NO: BJKV32
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 2014, Idaho wheat growers harvested around 1 million acres of wheat, of which 69% was winter and 31% spring wheat (www.idahowheat.org). Most of wheat production in the southern part of the state is grown under irrigation. 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, improved disease resistance, and desirable end-use quality. 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. Most of wheat cultivars are susceptible to FHB. 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 wireworm. This year pre-harvest sprouting damage resulted in over $100 million dollars losses for our wheat growers in Idaho.

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, wheat by maize di-haploid (DH) system, and molecular marker assisted selection (MAS). Objectives of this study are: 1) To develop desired wheat cultivars via traditional breeding; 2) To accelerate wheat cultivar development via di-haploid system and MAS; 3) To identify and validate QTL/markers associated with yield, end-use quality, resistance to biotic and abiotic stresses.

PROCEDURES:
Breeder Seed Production: A two-year breeder seed production system was developed in 2012 and used in this grant. The first year breeder seed production (B1) is to grow 400 headrows from 400 heads selected from a plot in the elite line strip trials (Gp10 and Gp100). The B1 headrows are selected based on uniformity and disease resistance if occurs. The selected B1 headrows are individually harvested and tested for protein and test weight and some of headrows with low test weight will be discarded. The final selected headrows are planted in yield plots in the second year breeder seed production (B2), simultaneously, tea spoon grain of each B2 plots are tested in disease nurseries (stripe rust, dwarf bunt, FHB). The B2 plots are selected based on uniformity and disease resistance and composited to form final breeder seed for foundation seed production

in the following year.

In FY 16, we are expecting to harvest B2 breeder seed for one hard white winter line IDO1101 and one soft white winter wheat dihaploid line IDO1108DH. IDO1101 is adapted for irrigated production. It is short and early, has good yield performance, high protein content and test weight, and good resistance to stripe rust and dwarf bunt. IDO1108DH has good yield performance in low pH soil. It also has good resistance to stripe rust and dwarf bunt. It is tall but has strong straw under dryland and irrigated production. We are also expecting to harvest B2 breeder seed for one hard white winter dihaploid line IDO1209DH, two soft white winter lines IDO1004 and IDO1005. In addition, we are expecting to harvest B1 breeder seed for two hard red and two hard white dihaploid lines for irrigated production. For spring wheat we are expecting to harvest B2 breeder seed for two soft white spring (M12001 and M12003), three hard white spring (IDO1202S, IDO1203S, M12008), two hard red spring (IDO862E and IDO862T). We are also expecting to harvest B1 breeder seed for three hard red spring wheat lines with FHB resistance.

Elite and Breeding 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 in SE ID. 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. Elite 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 Ardent 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 the 2014, two HRW and two HWW DH lines were entered into Tri-state Variety Trials, and additional 15 lines were entered into Western Regional trials. Three hundred elite lines are being tested in four to six locations, around two thousands breeding lines are being evaluated in one to two environments in SE ID.

Headrow Evaluation: Headrows will be planted in Aberdeen and be assessed for plant type and agronomic characteristics and disease resistance. 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 2014, we planted around 6000 winter wheat headrows. In the spring of 2015, we are going to 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 2014, we planted 160 headrows for winter F1 and 480 headrows for IDO1005 pre-breeder seed production. In spring 2015, we will plant 200 headrows for spring F1 and 1200 headrows for three lines of pre-breeder seed production.

Early Generation Test (F2, F3, and F4): 786 populations of F2 and F3 will be advanced with modified bulk selection and 105 F4 populations will be advanced with head selection in non-replicated trials in irrigated and water stress environments in SE ID.

Molecular Marker Assisted Breeding: Several populations were derived from crosses between Lassik and breeding lines with Hessian fly resistance gene H25 and good baking quality. Lassik has high protein gene GPC-B1 and stripe rust resistance gene Yr36 as well as resistant marker allele at Umn10 associated with FHB1 gene to Fusarium head blight. Molecular markers associated with these genes were screened for plants from F2 to F6. In 2014 around 400 lines were selected based on both molecular markers and agronomic performance. These lines will be evaluated in yield trials; some of these lines will be genotyed by GBS platform to identify SNPs for specific gene recombinants in 2015-2016.

Ten populations were derived from backcrossing marker assisted selection for novel resistance genes Sr39 and Sr47 to Ug99 (Klindworth et al., 2012), which were pyramided in the adapted lines with resistance genes to FHB and stripe rust. These populations will be advanced mainly by MAS.

Marker Development:

Molecular markers associated with FHB: Type II FHB resistance in RILs derived from UI Stone x Alturas has been assessed in four greenhouse experiments previously. The RILs of this population were planted in two nurseries in Louisiana State University to assess field resistance in FY16. We are expecting to identify markers associated with type II and field resistance in FY16.

Molecular markers associated with dwarf bunt and snow mold: One RIL (RioBlanco x IDO444) and one DH (Moreland x IDO835) populations were planted in snow mold nurseries in WA and ID, in dwarf bunt nursery in UT to identify markers associated with DB and SM in FY16 and FY17. Genetic map of the RioBlanco x IDO444 has been completed in the previous projects. The genetic map of the second population will be constructed using GBS platform by FY17.

Molecular markers associated with end-use quality in hard white background: Two hard white DH populations were developed from UI Silver x Shaan89150 and Capstone x UI Platinum, respectively, to identify markers associated with bread baking quality. The two populations will be genotyed by GBS, SNP, and SSR, simultaneously evaluated for agronomic performance and baking quality in FY16. This study will be coordinated by a visiting Ph.D student from P. R. China.

DURATION: 2nd of 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; 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; Pendlton Flour Mills: R. McLean; WestBred: D. Clark; LimaGrain: J. Peterson; 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, and publications in Journal of Plant Registration and other journals. QTL and molecular markers identified will be used in the breeding programs in the US and the world and published in peer referred journals and presented at national and international meetings. Students involved in the projects will be trained and worked in public and private sectors after graduated.

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, grain protein content, grain hardness, 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 (SNP and GBS) 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 dihaploid production will accelerate breeding cycles significantly.

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COMMODITY COMMISSION BUDGET FORM

Allocated by	Idaho Wheat Commission	during FY 2014	$ 240,665
Allocated by	Idaho Wheat Commission	during FY 2015	$166,254

REQUESTED FY 2014 SUPPORT:

	Salary*	Temporary Help**	Fringe ***	Travel****	OE*****	CO******	Grad Fees	TOTALS
Idaho Wheat Commission	$ 35,703	$ 45,325	$ 34,087	$ 15,000	$ 40,000	NA	NA	$ 170,115

OTHER RESOURCES (not considered cost sharing or match):

a) Industry (BASF, July - Dec)	$ 5,000
b) UI (salaries, operating, July - June)	$ 109,614
c) USDA-TCAP (July - Dec)	$ 50,000
TOTAL OTHER RESOURCES	$ 164,614

TOTAL PROJECT ESTIMATE FOR FY16:	$ 170,115 *(Requested)*	$ 164,614 *(Other)*	$ 334,729 *(Total)*

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 $ -

* $35703 is requested to cover 50% of two staff member's salary for 26 pay periods.
** Wage for four full time IH working for 3-6 months, and one college student working for four months in summer break.
*** 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 produce 200 DH lines.