PROJECT NO: BJKW37

TITLE: Developing Soft White Winter Wheat for Idaho

PERSONNEL: Robert Zemetra, Professor (208-885-7810)
Thomas Koehler, Research Support Scientist II (field) (208-885-6519)
Mackenzie Ellison, Research Support Scientist I (lab) (208-885-5829)

ADDRESS: Robert Zemetra, PSES Department, University of Idaho, Moscow, ID 83844-2339; 208-885-7810; *rzemetra@uidaho.edu*

JUSTIFICATION:
Soft white winter wheat is one of the major agricultural commodities in Idaho. To maintain producer profitability, new soft white winter wheat cultivars need to be produced that reduce input costs and increase return to producers through increased yield. Input costs can be reduced by incorporating resistance/tolerance to abiotic stresses like low winter temperatures or drought and biotic stresses such as diseases and insects. In addition to conventional sources of disease resistance, genetic engineering can be utilized to provide resistance to virus diseases such as Barley Yellow Dwarf (BYDV) through siRNA. Increased return to the producers can be achieved by increasing yield and increasing demand for Idaho wheat through incorporation of superior end-use quality. To achieve these objectives, the breeding project will use a collaborative approach utilizing individuals from various disciplines incorporating both conventional breeding and newer plant molecular techniques. One challenge to the success of this program is the reduction in support for the salaries of the research support scientists associated with the breeding program. It is essential to maintain the salaries of the support scientists to insure the continuity of the breeding program.

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. 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 for Pseudocercosporella foot rot and Cephalosporium stripe.
3) Develop and integrate new molecular markers to facilitate genotypic selection of desired traits in the soft white winter wheat breeding program.
4) Utilize a soft white winter wheat recombinant inbred line population for identification of molecular markers associated with traits of interest to Pacific Northwest wheat producers.
5) Develop and evaluate lines with herbicide resistance to be used as a tool to control grassy weeds in wheat.

6) Utilize genetic transformation to develop wheat plants with improved virus resistance.

PROCEDURES:

Breeding Improved Soft White Winter Wheat Cultivars: Research will be conducted in the field, greenhouse, and laboratory. Primary research emphasis will be on cultivar development. New sources of germplasm will be evaluated for traits of interest from programs in the Pacific Northwest. Crosses between desired genotypes will be made in the greenhouse. 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 done using molecular markers associated with the trait to insure lines being advanced carry the genes of interest. Early generation material (F_2 - F_4) will be evaluated in the field for disease resistance, agronomic traits, and seed quality. Intermediate generation material (F_5 - F_6) will be evaluated for the same traits plus yield, test weight, milling quality, starch quality, starch color, noodle color, and baking quality. Lines selected in the F_5 and F_6 generations will also be evaluated for resistance to stripe rust, Pseudocercosporella foot rot and Cephalosporium stripe using molecular markers and in inoculated nurseries. Lines selected for advancement from the F_5 to F_6 generation will be screened for falling number to identify lines with high and or low falling number scores. Lines advanced from the F6 nursery will be evaluated for late maturity alpha-amylase in the greenhouse. Advanced generation material (F_7 - F_8) will be evaluated for stability of these traits across six rainfed northern Idaho locations and three irrigated southern Idaho locations. The southern Idaho locations are grown in Aberdeen by J. Chen, in Kimberly by J. Windes, and in Parma in cooperation with B. Brown. Stripe rust resistance evaluation will be done on the advanced generation material in cooperation with X. Chen, USDA-ARS. In cooperation with K. O'Brien, F_5 and advanced generation lines will be tested for domestic and foreign end-use quality. A tri-state cooperative irrigated trial will be grown in Parma and Aberdeen to evaluate lines for superior performance under irrigation. The tri-state irrigated trial is in cooperation with B. Brown, J. Chen, and public and private breeders in the Pacific Northwest. 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 B. Brown, J. Marshall and Doug Finkelnberg. These lines are also tested at this time in extension trials in Washington and Oregon. 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.

End-use quality research is in cooperation with K. O'Brien. Grain protein, hardness, milling quality, noodle color, and baking quality of intermediate and advanced lines will be evaluated at the Aberdeen Wheat Quality Laboratory. Polyphenol oxidase testing will be done on intermediate and advanced lines in Moscow as part of undergraduate training. SRC (solvent retention capacity) testing of intermediate and advanced material will be done in cooperation with K. O'Brien. Stirring number testing will be done on intermediate material to evaluate lines for LMA (late-maturity amylase).

Improving Disease Resistance in Soft White Winter Wheat: Basic disease resistance research will center on developing and utilizing molecular markers for resistance genes for Pseudocercosporella foot rot and Cephalosporium stripe. Lines will be tested using an improved molecular marker for the *Pch1* resistance gene developed by a joint UI – OSU - USDA-ARS effort to identify intermediate and advanced lines to select lines with resistance to Pseudocercosporella foot rot. Genotypes with varying levels of Cephalosporium stripe resistance/tolerance will be developed for use in identifying molecular markers associated with resistance to this disease. A second area of basic research on Cephalosporium stripe is the development of a simple laboratory screening method for resistance/tolerance. A third area of basic disease research is the utilization of a new generation of constructs for use in genetic transformation of wheat for improved BYDV resistance in collaboration with A. Karasev and N. Bosque- Pérez. Doubled haploid technology will be used to create homozygous lines from T_1 BYDV construct plants to develop homozygous lines carrying various number of gene constructs. These lines will be tested in the lab and greenhouse for level of induced resistance and gene stability.

The applied disease resistance research will be based on field screening for disease response in inoculated (Pseudocercosporella foot rot and Cephalosporium stripe) or naturally infected fields (stripe rust and dwarf bunt). Crossing will continue to combine the best genetic sources for Cephalosporium stripe resistance/tolerant from lines developed at Washington State University, Oregon State University and the University of Idaho to pyramid genes for resistance to this disease.

Development of Herbicide Resistant Soft White Winter Wheat: Development of one gene and two gene imazamox resistant wheat cultivars will with the goal to develop adapted herbicide resistant cultivars for use in managing grassy weeds such as jointed goatgrass and downy brome in wheat. One single gene resistance line 02-475-2DH is currently under consideration for release in 2011. Two gene resistance lines for imazamox resistance are now in preliminary field evaluation. Doubled haploid technology is being utilized with the two gene herbicide resistant wheat program to rapidly develop homozygous resistant two gene lines. Research is currently underway to develop a more accurate and efficient method to identify homozygous two gene resistant lines using a Pyromark Q24 sequencer. This work is being done in collaboration with J. Kuhl.

Molecular Biology Research for Improvement of Soft White Winter Wheat: Basic research in the molecular biology of winter wheat will involve work in transgenics for BYDV resistance and in developing molecular markers for improvement of winter wheat. The BYDV resistance will be introduced into the soft white winter wheat cultivars Brundage 96 and Simon through particle gun bombardment of callus of the two cultivars. The introduced construct will carry a short BYDV nucleic acid sequence that will induce short interfering RNA (siRNA) gene silencing, preventing virus replication in transgenic plants.

Work will continue with the recombinant inbred line population CB-2 developed from the cross Brundage x Coda. The Coda-Brundage RIL population has already been used to develop molecular markers for Cercosporella foot rot (UI, OSU, USDA-ARS), and is currently being used to develop molecular markers for stripe rust (WSU) and winterhardiness (WSU and USDA-ARS).

DURATION: 5 years (2011-2015)

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
David Hole	Wheat Breeder	Utah State University
Arron Carter	Wheat Breeder	Washington State University
Oscar Riera-Lizarazu	Wheat Geneticist	OSU-Corvallis
Brad Brown	Extension Agronomist	UI- Parma
Juliet Marshall	Extension Agronomist	UI-Idaho Falls
Stephen Guy	Extension Agronomist	WSU-Pullman
Michael Flowers	Extension Agronomist	OSU-Corvallis
Donn Thill	Weed Science	UI-Moscow
Roy Patten	Farm Manager	UI-Moscow
Xiaming Chen	Mycologist	USDA-ARS Pullman
Chris Mundt	Mycologist	OSU-Corvallis
Tim Murray	Mycologist	WashingtonState University
Joseph Kuhl	Molecular Biologist	UI-Moscow
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. Development of molecular markers and molecular marker capabilities will allow for more efficient screening for disease resistance. Research in the genetic transformation of PNW wheat will allow for the creation of new sources of virus resistance in soft white winter wheat cultivars adapted to the PNW. 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 soft white winter wheat breeding program has been the development of improved soft white winter wheat cultivars for the wheat producers of Idaho that have both improved yield potential and superior end-use quality. Examples of such cultivars are Brundage (Zemetra et al 1998) and Brundage 96 (Zemetra et al 2003). The breeding program has also emphasized maintaining and improving resistance to diseases that are problems to producers in the Pacific Northwest, specifically stripe rust, Pseudocercosporella foot rot and Cephalosporium stripe. An example of an Idaho cultivar that was developed with foot rot resistance is Simon soft white winter wheat. Field selection for resistance to foot rot can be difficult but the recent development of a new molecular marker for *Pch1* by a collaborative effort of OSU, UI and

USDA-ARS scientists (Leonard et al. 2008) has improved efficiency of selection for strawbreaker foot rot. With Cephalosporium stripe, resistance/tolerance appears more quantitative in nature so development of resistance/tolerance to this disease is being done by crossing the best lines for Cephalosporium stripe resistance/tolerance from the three PNW winter wheat breeding program. The use of siRNA to prevent expression of host and non-host genes (virus genes) in plants has been shown to work successfully in several plant species (Ossowski et al. 2008). If successful in wheat, siRNA gene silencing could be a new source for virus resistance to diseases such as BYDV and Wheat Streak Mosaic (WSMV).

CITATIONS:

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

Ossowski, S., R. Schwab, and D. Weigel. 2008. Gene silencing in plants using artificial microRNAs and other small RNAs. *The Plant Journal* 53: 674-690.

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.

COMMODITY COMMISSION BUDGET FORM
BJKW37

Allocated by	Idaho Wheat Commission	during FY 2010	$ 76,592
Allocated by	Idaho Wheat Commission	during FY 2011	$ 99,070

REQUESTED FY 2012 SUPPORT:

	Salary	Temporary Help	Fringe	Travel	OE	CO	Grad Fees	TOTALS
Idaho Wheat Commission	$ 36,257	$ 40,000	$ 20,080	$ 11,000	$ 22,000	$ -	$ -	$ 129,337

OTHER RESOURCES (not considered cost sharing or match):

a) Industry	$ 10,000
b) UI (salaries, operating)	$ 91,725
c) Other (local, state)	$ -
d)	$ -
e)	$ -
TOTAL OTHER RESOURCES	$ 101,725

TOTAL PROJECT ESTIMATE FOR FY 2012:	$ 129,337 *(Requested)*	$ 101,725 *(Other)*	$ 231,062 *(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 $ -

11.3.2010 - Version

CURRENT AND PENDING SUPPORT:

Name: Robert S. Zemetra

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/Active:				
Zemetra, R.S.	Idaho Wheat Commission	$99,070	7/1/2010-6/30/2011	30%	Developing soft white winter wheat for Idaho
Zemetra, R.S.	USDA-ARS , Wheat CAP	$47,500	10/01/08 – 11/31/10-	5%	Wheat applied genomics
Windes, J.M., B. Brown, D. Finkelnburg, and R.S. Zemetra	Idaho Wheat Commission	$25,052	7/1/2010 to 6/30/2011	2%	Education for Idaho wheat producers: Extension cereal nurseries
Zemetra, R.S.	Idaho Wheat Commission	$10,270	7/1/2010 – 6/30/2011	2%	Support Scientist funding
Zemetra, R.S.	Idaho Barley Commission	$10,960	7/1/2010 – 6/30/2011	2%	Education for Idaho barley producers: Extension cereal nurseries
Zemetra, R.S.	Idaho Barley Commission	$5,285	7/1/2010 – 6/30/2011	2%	Support Scientist Funding
Zemetra, R.S.	U.S. Dry Pea and Lentil Council	$19,000	7/1/2010 – 6/30/2011	5%	Variety Development and Education for Pea, Lentil and Chickpea with Extension Variety Trials in Northern Idaho
Zemetra, R.S.	Washington Grain Commission	$11,000	7/1/2010 – 6/30/2011	4%	Testing advanced breeding lines for high production areas in the Pacific Northwest
Zemetra, R.S.	CREES special grant	$347,000	8/01/08 – 7/31/11	5%	PCN-Idaho
Zemetra, R.S.	CREES special grant	$325,368	9/01/09 – 8/31/11	5%	PCN-Idaho
Zemetra, R.S.	CREES special grant	$325,400	9/1/2010-8/31/2011	5%	PCN-Idaho
	Pending:				

Zemetra, R.S., J. Chen, D. Hole	USDA-NNF	$249,000	1/1/2011 – 12/31/2114	15%	Developing the next generation of neoclassical plant breeders
Coleman, Zemetra, et al.	USDA-NIFA Biomass Research and Development Initiative	$6,966,397	6/1/2011 – 5/31/2015	5%	Mobile fast pyrolysis of forest biomass and agricultural residues for biofuel production
Zemetra, R.S.	U.S. Dry Pea and Lentil Council	$17,454	7/1/2011 – 6/30/2012	5%	Pea, Lentil and Chickpea Extension Variety Trials in Northern Idaho
Zemetra, R.S.	Idaho Wheat Commission	$9,800	7/1/2011 – 6/30/2012	2%	Support Scientist funding
Zemetra, R.S.	Idaho Barley Commission	$5,040	7/1/2011 – 6/30/2012	2%	Support Scientist Funding
Zemetra, R.S.	Idaho Wheat Commission	$129,337	7/1/2011-6/30/2012	30%	Developing soft white winter wheat for Idaho

Peer Review Verification:

Reviewer 1: Alex Karasev A. Karasev (Signature) 12/21/10 (Date)

Reviewer 2: Joseph Kuhl (Signature) 12/21/10 (Date)

Dept. Head/ Unit Administrator: Ding Johnson James B. Johnson (Signature) 21 Dec. 2010 (Date)

PROGRESS REPORT

PROJECT NO: BJKW37

TITLE: Developing Soft White Winter Wheat for Idaho

PERSONNEL: Robert Zemetra, Professor (208-885-7810)
Thomas Koehler, Research Support Scientist II (field) (208-885-6519)
Mackenzie Ellison Research Support Scientist I (lab) (208-885-5829)

ADDRESS: Robert Zemetra, PSES Department, University of Idaho, Moscow, ID 83844-2339; 208-885-7810; rzemetra@uidaho.edu

CHANGES IN PERSONNEL

After many years in the University of Idaho Soft White Winter Wheat Breeding Program Jenny Hansen, the Research Support Scientist in charge of the lab and greenhouse, left the program to work in the winter wheat breeding program at Washington State University. To replace Jenny the breeding program was able to hire Mackenzie Ellison. Mackenzie had recently received a Master's degree from the University of Idaho and had worked in the soft white winter wheat breeding program during his graduate degree. He brings skills in both the laboratory and field to the breeding program.

ACCOMPLISHMENTS:

The objective of the soft white winter wheat breeding program is to develop high yielding, high quality soft white winter wheat cultivars for Idaho and the Pacific Northwest. To meet the needs of the wheat producers in southwestern Idaho the breeding program is planning on releasing ID98-19010A in Spring 2011. ID98-19010A is a high yielding, excellent end-use quality advanced line that is well adapted for production in the irrigated growing areas of southern Idaho, especially in the Treasure Valley. It is susceptible to stripe rust so its production area would be limited to the southern production areas of Idaho. A second line, 96-16702A, is being evaluated for release in 2011. It is a high yielding advanced line with good stripe rust resistance and similar end-use quality to Brundage 96 that appears adapted to both rainfed and irrigated growing conditions. This line is currently being evaluated for end-use quality by the Pacific Northwest Wheat Quality Council. With the release of UICF-Lambert and UICF-Brundage the herbicide resistant wheat research has increased its emphasis on the development of 2-gene imazamox resistant wheat with the first field trial being conducted in 2010. Research on identifying molecular markers useful to developing improved disease resistance in soft white winter wheat continued with phenoytping the Coda – Brundage recombinant inbred line population (CB-2) for response to stripe rust. Transgenic wheat was produced carrying stem-loop constructs created in the UI-soft white wheat breeding and genetics lab to induce resistance to BYDV and reduce straw lignin content though siRNA silencing.

1) Develop new soft white winter wheat cultivars.

98-19010A: Potential soft white winter wheat line being considered for release in Spring, 2011. 98-19010A is early, short and has excellent yield potential under irrigation. End-use quality of 98-19010A is excellent, exceeding that of Brundage and Brundage 96 in break flour yield and

sugar snap cookie diameter. The line is susceptible to stripe rust so would be limited to growing areas where Brundage wheat can be produced. A small Breeder/Foundation seed field has been planted at the UI-Parma Research and Extension Center. The tentative name for 98-19010A is 'Branen'.

96-16702A: Advanced soft white winter wheat line being considered for release in Fall, 2011. 96-16702A is similar in height to Bitterroot and has excellent yield potential under both rainfed and irrigated conditions. It has good resistance to stripe rust and has good to excellent end-use quality. 96-16702A has also been reported to have good end-use quality in whole grain products. It has been submitted for evaluation by the Pacific Northwest Wheat Quality Council in 2011.

Development and testing of soft white winter wheat germplasm continues in multiple locations throughout the state. Several of the northern Idaho advanced yield trials and one location for the F_6 nurseries are planted using a direct seed drill to better emulate producers' conditions. Evaluation of end-use quality starts in the F_4 generation and is done by K. O'Brien at the Wheat Quality Laboratory in Aberdeen. The tri-state irrigated nursery continued in 2010 in 8 locations in the PNW (2 – southern Idaho, 2 eastern Oregon and 3 eastern Washington). The two southern Idaho locations were planted in cooperation with J. Chen, Aberdeen and B. Brown, Parma. The two eastern Oregon locations were planted in collaboration with M. Flowers (OSU). The three eastern Washington locations were planted by this program with funding from the Washington Wheat Commission. The eastern Washington locations will be taken over by A. Carter in July, 2011.

2) Development of imazamox resistant soft white winter wheat lines.

One additional single gene herbicide resistant line is under consideration for release, 00-475-2DH. This line is high tillering, has moderate straw strength, good to excellent yield potential and excellent end-use quality but appeared to have lower stripe rust resistance than desirable in 2010. It will undergo additional evaluation in 2011 before any decisions are made concerning its release.

Development of the second generation of herbicide resistant germplasm with two genes for imazamox resistance continues with the production of backcrosses involving the current one gene imazamox resistant lines plus new releases such as Simon and Bitterroot as new recurrent backcross parents. The first field evaluation of the two gene imazamox resistant lines was done in 2009. Doubled haploid methodology was used to produce lines homozygous for both herbicide resistant genes for field testing of lines with Brundage 96, Simon and Bitterroot backgrounds in Fall, 2010.

3) Improve the level of disease resistance in the soft white winter wheat program's germplasm for Pseudocercosporella foot rot, Cephalosporium stripe, and dwarf bunt.

Field evaluation was done for Pseudocercosporella foot rot, Cephalosporium stripe and dwarf bunt resistance by both the UI breeding program and programs at Washington State University and Oregon State University. Results from the Oregon State University trial for Cephalosporium stripe tolerance indicated that Bruneau carried a similar level of resistance to that of Bitterroot. Disease levels were good in the trials inoculated with Cephalosporium stripe or Pseudocercosporella foot rot allowing for the collection of useful phenotypic data in 2010. Due

to a milder than normal winter in terms of snow, dwarf bunt evaluation at the Cavendish location yielded little data on resistance to dwarf bunt in the UI advanced lines.

4) Integrate new biochemical and molecular techniques for selection into the soft white winter wheat breeding program.

The CB-2 recombinant inbred line population was successfully used to develop QTL molecular markers Cephalosporium stripe tolerance by C. Mundt and J. Peterson, OSU. The population has been planted for evaluation for stripe rust resistance and winter-hardiness in collaboration with A. Carter, the new winter wheat breeder at WSU. Evaluation of the population for variation for the QTL molecular markers associated with late maturity alpha-amylase (LMA) will be done in to determine if the population can be used to develop improved molecular markers for genotypic selection of lines with low LMA response in the field.

F_5 generation material is now routinely screened in the laboratory for polyphenol oxidase (PPO) level by undergraduate research assistants using the technique developed at the Western Regional Wheat Quality Laboratory in Pullman. This information is used in the selection of lines for advancement into the F_6 generation. F_5 and F_6 generation material is now screened for the *Pch1* gene using the molecular markers developed using the CB-2 population.

5) Use of genetic transformation to create resistance to BYDV and/or modify gene expression in wheat to enhance the potential for wheat straw to be used as a ligno-cellulosic feedstock for ethanol production.

Genetic constructs were completed to induce small interfering (si) RNA in wheat to either prevent replication of Barley Yellow Dwarf virus (BYDV) in wheat or down regulate expression of a gene in the lignin biosynthesis pathway in wheat. The BYDV construct would confer resistance to BYDV by preventing its replication in wheat. Development of this construct was funded by Idaho Wheat Commission funds in 2008 and 2009. The lignin construct targets the CCR1 gene and would reduce the level of lignin produced in the wheat stem, making the straw a better substrate for use in ethanol production. Each construct has been introduced into the wheat cultivars Brundage 96 and Simon via particle bombardment of wheat callus. Plants have been regenerated from the transformed callus and will be tested in Spring, 2011 to identify plants carrying the introduced genetic construct and initiate evaluation of effectiveness of the inserted gene. T_1 plants will be used as source plants for dihaploid plant production to produce plants that are homozygous for the transgene and that carry various number (2, 4, 6 etc.) copies of the transgene. The dihaploids will be used to produce seed for evaluation of the induced trait in replicated trials.

PROJECTIONS:

Progress continues to be made in the breeding program in the development of high yielding soft white winter wheat cultivars with superior end-use quality and improved levels of disease resistance/tolerance. Adoption of these cultivars by Idaho producers should increase both production and end-use quality of soft white winter wheat produced in Idaho. Molecular markers developed from germplasm developed by this program should lead to the release of cultivars in the future with improved resistance/tolerance to diseases that impact wheat productivity in the Pacific Northwest. Herbicide resistant soft white winter wheat cultivars released by this program will be available for use by Idaho wheat producers as a tool in the management of grassy weed

species. Both genetic transformation and molecular marker assisted selection will continue to be evaluated as components in the soft white winter breeding program.

PUBLICATIONS:

Chen, J., E.J. Souza, N.A. Bosque-Pérez, M.J. Guttieri, K.L. O'Brien, J.M. Windes, S.O. Guy, B.D. Brown, X.M. Chen, and R.S. Zemetra. 2010. Registration of 'UI Winchester' Wheat. *Journal of Plant Registration* 4:1-4

Finkelnberg, D. and R. Zemetra. 2010. 2009 Small Grain and Grain Legume Report. University of Idaho Research Bulletin No. 176.

Koehler, T.J., R.S. Zemetra, and K. O'Brien. 2010. 2005-06 and 2006-07 Idaho wheat yield trials. University of Idaho. Progress Report No. 385.

Koehler, T.J., R.S. Zemetra, and K. O'Brien. 2010. 2007-2008 Idaho wheat yield trials. University of Idaho. Progress Report No. 386.

Li, Z., Y. Liu, W. Liao, S. Chen, and R.S. Zemetra. 2010. Bioethanol production using genetically modified and mutant wheat and barley straws. Biomass and Bioenergy (in press)

Zemetra, R.S., M. Flowers, and J. Chen. 2010. Breeding better wheat. Wheat Life (November) pgs 58-61.