Progress Report to the Agricultural Research Foundation
Oregon Wheat Commission

PROJECT: Development of wheat varieties adapted to Oregon production with enhanced disease resistance, stress tolerance, and superior end-use qualities

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FUNDING HISTORY:

2002-2003	120,000
2003-2004	200,816
2004-2005	208,098

ABSTRACT:

The goal of the OSU Wheat Breeding program is to develop varieties that can increase economic returns to Oregon growers through improved grain yield, disease resistance, and enhanced end-use qualities for marketing. In collaboration with BASF, two CLEARFIELD varieties have been developed for their utility in control of grassy weeds in combination with applications of Beyond™ herbicide. The OSU CLEARFIELD soft white winter variety 'ORCF-101' was released to the seed industry in 2003 through an innovative non-exclusive licensing agreement. A second CLEARFIELD variety, 'ORCF-102', was released in fall, 2004, through the same licensing agreement. ORCF-102 was derived from the cross 'Madsen/FS-4//Weatherford' and has superior tolerance to root diseases, particularly Cephalosporium stripe and Strawbreaker footrot. ORCF-102 may be preferred by growers that need a CLEARFIELD variety for no-till or reduced tillage management situations. Eighteen seed companies have now been licensed to produce and sell seed of OSU CLEARFIELD varieties in the Pacific Northwest. An estimated 250,000 acres of ORCF-101 were planted by wheat growers in fall, 2004. The soft white winter wheat selection OR9801757 was advanced to Foundation seed increase for possible release in 2005. OR9801757 is noted for its superior milling and baking quality, low grain protein content, and exceptionally soft grain texture. It also has a superior yield record in the drier production areas of Sherman and Gilliam counties of North Central Oregon. Because of its superior end-use quality, OR9801757 presents a unique opportunity to develop an identity preserved production and marketing program for the Oregon wheat industry. Due to reduced funding for extension programs, a modified state-wide variety testing program was designed and integrated into our breeding trials in 2004. The Oregon Winter Elite Yield Trial (OWEYT) was designed to support breeding efforts, end-use quality testing, variety release decisions, variety quality recommendations, and provide performance data to growers. Data were obtained from

only 9 of 12 locations in 2004 due to drought conditions and difficulties in fall stand establishment. Hard white wheat breeding efforts have been focused on improving end-use quality for Asian noodle products through crosses with Plains hard wheat germplasm. The first series of F5 lines from these crosses were evaluated this past year. Ninety two of the most promising hard white lines were advanced to multilocation yield trials.

OBJECTIVES:

1. Develop and release new wheat varieties with superior disease resistance and enhanced tolerance to abiotic stresses that minimize production risks and increase economic returns to growers.
2. Provide growers with up-to-date information on near-release and newly released varieties in comparison to currently grown varieties through field days and print and web media.
3. Increase demand and marketability of PNW wheat through development of soft and hard wheat varieties with superior end-use qualities. Identify germplasm, genes, and traits that contribute value-added or product-specific qualities and provide new marketing opportunities for wheat growers.
4. Identify germplasm, genes, and traits that will contribute to superior varietal performance and enhanced yield stability under diverse production conditions. Incorporate these new genetic resources and products of biotechnology into adapted varieties through efficient use of field and laboratory evaluation methods.
5. Integrate Hybritech winter wheat breeding stocks into the OSU breeding program for use in pureline variety development efforts in the PNW. Evaluate selected populations and advanced lines for yield potential, agronomic traits, winterhardiness, response to Stripe rust, and end-use quality.

PROCEDURES:

Varieties and breeding materials must be evaluated under a wide array of environmental and management practices to characterize performance and adaptation. Early generation breeding materials (F1 through F5) are evaluated through a shuttle between Hyslop and Pendleton (Ruggs) to identify broadly adapted, disease resistant selections. Mid-late generation materials, (preliminary and advanced lines of F6 through F9) are evaluated in replicated trials at our core nursery sites at Pendleton (Rugg-Barnett), Moro (Sherman County Experiment Station), and Corvallis (Hyslop Research Farm). In addition, six 'satellite' testing nurseries are used to more rapidly characterize performance of our breeding lines. Each site includes three replications of the OWEYT, one or two replications of Advanced SW and HW nurseries, and unreplicated plots or observation rows of lines in preliminary and advanced yield trials (F6 through F8 generations). In fall 2003, the nurseries were planted at sites near Moro (Chris Kaseberg), Condon (Jeff Nelson), Arlington (Eric Anderson), Lexington (Chris Rauch), Hermiston (Kent Madison), and Moses Lake, (John LaFave, for winterhardiness testing). These sites were chosen to represent a very diverse array of production conditions; from very low rainfall to full irrigation, shallow to deep soils, and low residue to high residue management practices. With these diverse experimental locations we except to more rapidly

characterize performance of our breeding lines and parent stocks for adaptation, yield potential, stress tolerance, and disease resistance.

For the 2003-04 crop year, due reduced funding of state extension programs, a modified state-wide variety testing program was initiated and trials were incorporated into our breeding trials. The Oregon Winter Elite Yield Trial (OWEYT) and Oregon Spring Elite Yield Trial (OSEYT) were established to collect important performance data needed for breeding, variety release and co-release decisions, and reports to the seed industry and Oregon growers. New varieties and variety candidates, both public and private, from throughout the region are evaluated in the trials. In addition to 9 locations of winter wheat breeding trials, the OWEYT was evaluated at Madras, LaGrande, and Ontario in cooperation with researchers at the OSU Ag Research Centers. The OSEYT was evaluated at a limited number of sites, including Corvallis, Pendleton, and Klamath Falls. Due to increasing interest in winter wheat in the area, both the OSEYT and OWEYT will be evaluated at Klamath Falls in 2005. Grain samples from the OWEYT and OSEYT are used for end-use quality analyses to support wheat quality improvement efforts, release decisions, variety recommendations, and information for future marketing activities. Results from the OWEYT and OSEYT are posted on our project web site and distributed electronically throughout the region.

As an indication of project activities and scope, a summary of winter wheat plantings for 2005 is attached. The spreadsheet indicates number of entries, replications, and test sites for each breeding trial. The list does not include F1's, headrows (approx. 40,000 rows in F2-F5 generations), thesis research trials, or crossing blocks. There are no separate 'Hybritech yield trials' for 2004 or 2005, as the Hybritech stocks are fully integrated into our advanced breeding trials.

Germplasm collaborations and exchange are continuing priority. In 2004, we will be evaluating over 200 varieties and germplasms from the Nickerson breeding programs, which are located in England and France. Forty lines from Nickerson that were screened in 2001 through 2004 have been advanced to multilocation replicated yield trials for more detailed characterization of adaptation, yield potential, and disease resistance. Over 150 winter wheats were imported from CIMMYT-Turkey as candidates for the Eastern European Regional Yield Trial and FAWWON. Quarantine increase, evaluation and characterization of new spring wheat germplasms from CIMMYT continues, including those selected on-site in Obregon in 2004.

REPORT OF ACCOMPLISHMENTS:

New varieties and performance updates:

'Tubbs' soft white winter wheat was released in 2002 for its superior yield potential and broad adaptation. Tubbs has performed exceptionally well in variety trials throughout the PNW over the last four years and it was at the top of the WSU Variety Trials again in 2004. Certified seed was widely available for the first time in fall, 2004, and seed stocks were in great demand. Tubbs is most quickly being adopted in areas that have

traditionally planted Stephens, where it has shown an 8-10% yield advantage over Stephens. However, growers as far north as Highway 2 in Washington have planted Tubbs this past fall, often as a component in a variety blend. We expect Tubbs to be among the leading varieties in 2005 in terms of planted acreage in both Washington and Oregon.

Tubbs carries genes for high temperature adult plant (HTAP) resistance to Stripe rust from its soft white winter wheat parents Malcolm and Madsen. In 2004, a small number of Tubbs production fields in the Prescott, Washington, area had unusually severe stripe rust, to the point that fungicides were applied to control the disease. Fungicides also were applied to a limited number of irrigated fields of Tubbs in eastern Oregon and Washington. However, in most areas, both in production fields and test plots, Tubbs had little or no stripe rust. The rust situation on Tubbs appears to result from the interaction of unique cool weather conditions with crop development stage and genetics. Based on field tests over the past four years, Tubbs is apparently heterogeneous, or genetically mixed, for HTAP resistance genes. The variety appears to include least three types: 1) approximately 50% of the plants are highly resistant to stripe rust and have effective HTAP resistance; 2) from 30 to 50% of the plants are moderately resistant to moderately susceptible; and 3) less than 5% of the plants are highly susceptible do not carry effective HTAP or seedling resistance. The second group may have fewer number of HTAP resistance genes such that the resistance is less effective under conditions with high inoculum load and unusually cool, wet weather or heavy irrigation. The resistance of this group should be adequate and effective under normal weather conditions in the eastern PNW, but may be marginal for the Willamette valley and western areas of the PNW.

'Foote' was released by OSU in 1998, targeted for the Willamette valley because of its superior resistance to Septoria leaf blotch. In 2004, production fields of Foote were sprayed up to three times with fungicide to control Stripe rust. Prior to 2004, the soft white winter wheat variety Foote was highly resistant to stripe rust. The experimental data and field observations indicate that Foote has seedling, or major gene, resistance that is not effective against this new race of stripe rust. Foote is not alone, as major gene resistances of several important PNW spring wheat varieties have been overcome in the last 2-3 years. Spring wheat varieties now susceptible to stripe rust include Penawawa, Zak, Wawawai, Treasure, Whitebird, Eden, Macon, and Scarlet. The rust race that attacked Foote in the Willamette valley has been identified as PST-100, plus virulence on the hard red variety Summit. Race PST-100 was common among California isolates in 2004 and predominated in 2003. Some of the 2004 California isolates of PST-100 had new virulence on the variety Summit. This indicates a virulence and race change for 2004. This race was not common in eastern Oregon or Washington this past growing season, but could be a problem next year. If Foote is grown in 2005, it should be monitored closely in the spring and fungicides applied as stripe rust develops.

'ORCF-101' was released to the seed industry in fall, 2003, through an innovative non-exclusive licensing agreement. ORCF-101 is a CLEARFIELD variety, developed in collaboration with BASF, and released primarily for its utility in control of grassy weeds with application of Beyond^{TM} herbicide. ORCF-101 is a semidwarf soft white winter

wheat derived from the three-way cross 'CV-9804'/'Malcolm'//'Stephens'/'Madsen'. ORCF-101 is adapted to production areas of northeast Oregon, southeast Washington, and Idaho and possesses adult-plant resistance to stripe rust (*Puccinia striiformis).* ORCF-101 is moderately susceptibility to most major diseases of the PNW, including Strawbreaker (*Psuedocercosporella*) footrot, *Septoria tritici*, crown rot (*Fusarium pseudograminearum)* and Cephalosporium stripe (*Cephalosporium gramineum*). Analyses conducted by the ARS- WWQL suggest that ORCF-101 has good overall milling quality, flour yield, protein content, and baking quality, and performs very similar to Stephens and/or Madsen. ORCF-101 is registered under the Plant Variety Protection act with the Title 5 option.

Eighteen seed companies have now been licensed to produce and sell seed of OSU CLEARFIELD varieties in the Pacific Northwest. An estimated 250,000 acres of ORCF-101 were planted by wheat growers in fall, 2004.

'ORCF-102' was released to the seed industry in fall, 2004, through the same semi-exclusive licensing agreement as ORCF-101. ORCF-102 is a CLEARFIELD variety derived from the cross 'Madsen/FS-4//Weatherford'. ORCF-102 is noted for its superior tolerance to root diseases, particularly Cephalosporium stripe and Strawbreaker footrot. ORCF-102 has high yield potential and superior grain test weights, but has taller plant height as compared with ORCF-101. ORCF-102 was released, in part, because of the relatively poor performance of 'Clearfirst', which was expected to be a viable CLEARFIELD variety for the traditional 'Madsen' growing area of the PNW. Herbicide tolerance and response of ORCF-102 and ORCF-101 are similar, and similar to Clearfirst.

Yield advantage of ORCF-102 over ORCF-101 and Idaho 587 has been most evident at the drier locations, or sites with significant root disease pressure. In inoculated trials and genetic marker analyses, ORCF-102 has been shown to carry the VPM resistance to strawbreaker footrot, with similar disease response to its parents Madsen and Weatherford. We failed to capture the VPM resistance in development of ORCF-101. Idaho 587, based on Stephens, also does not carry VPM. In inoculated Cephalosporium stripe trials, ORCF-102 has shown tolerance to the disease similar to that of Weatherford. ORCF-102 also appears to have better tolerance to Fusarium crown rot than ORCF-101, Stephens, or Tubbs. In USDA-ARS stripe rust evaluations, ORCF-102 has shown good levels of adult plant resistance, similar to Stephens, ORCF-101, or Tubbs. ORCF-102 is taller than ORCF-101 and Stephens and approximately 1 day later maturing than ORCF-101. End-use quality of ORCF-102, as evaluated through the USDA-WWQL and Wheat Quality Council, is considered satisfactory, similar to Stephens or Madsen. Grain test weights of ORCF-102 have been significantly higher than for ORCF-101 or Stephens.

All available Foundation seed of ORCF-102, approximately 32,000 pounds, was purchased by Seed Associates under license by OSU. We anticipate up to 50,000 bushel of seed to be available to growers in fall, 2005. A copy of the release document is attached.

OR9801757 was advanced to Foundation seed increase for possible release in 2005. OR9801757 is a soft white winter wheat derived from the cross: 'Yamhill/Hyslop//Stephens/3/OR7946/Hill//Hill (as selection WSQ910137) /4/Sambo/Heine 4//Stephens/3/Wattines//Yamhill/Hyslop' made in 1992. Yet to be named, OR9801757 is noted for its superior milling and baking quality, low grain protein content, and exceptionally soft grain texture. It also has a superior yield record in the drier production areas of Sherman and Gilliam counties of North Central Oregon. OR9801757 has higher average test weight as compared with Stephens and Tubbs, similar to that of Madsen and Weatherford. Plant height of OR9801757 is similar to Tubbs. OR9801757 is slightly earlier in maturity as compared with Stephens.

Because of its superior end-use quality, OR9801757 presents a unique opportunity to develop an identity preserved production and marketing program for the Oregon wheat industry. A copy of the release proposal and variety description is attached. A 50 acre field was planted in fall, 2004, for production of Foundation Seed. This field also is expected to provide grain samples for use in large-scale milling and baking evaluations.

Oregon Variety Testing:

The Oregon Winter Elite Yield Trial (OWEYT) was planted at 12 sites for the 2004 crop year. However, data were obtained from only 9 of the test sites. Fall 2003 planting conditions were very dry and trials were 'dusted in' at all the dryland sites. Emergence was delayed until widespread rains began in late November and December. Three sites (Arlington, Moro-Kaseberg, and Moses Lake) were abandoned due to poor fall stand establishment and/or severe wind damage. In early spring, crop stands were unusually thin and not well tillered. However, prolonged cool, wet conditions in May and June contributed to higher grain yields and helped compensate for late emergence, thin stands, or reduced fall growth. Although harvested, the nursery at the Sherman County Experiment Station was of little value because of extreme variability in N rate from plugged applicator. The OWEYT at Ontario was so severely lodged that varietal differences grain yield could not be determined.

Average grain yields for the OWEYT ranged from a low of 44.1 bu/a at Lexington to 146.6 bu/a under full irrigation at Hermiston. Leading varieties over locations were Westbred 528, Dune, Mohler, Simon, and Tubbs. It is notable that these are all new or recently released varieties. Our Pendleton nursery benefited from the favorable spring conditions, with average grain yields of 132 bu/a without any supplemental irrigation. Yields of individual varieties in the Pendleton OWEYT ranged from 114 to 148 bu/a. Breeding trials at Hyslop farm, which were disappointing in 2003, had good yields and plant development with OWEYT grain yields averaging 114 bu/a. Stripe rust was severe in the Willamette Valley. Rust developed early in the spring because of favorable environmental conditions and a heavy inoculum load coming from California. Susceptible varieties were defoliated by mid-May. The cool, wet spring was ideal for development of stripe rust, but not for root diseases such as Fusarium crown rot or Cephalosporium stripe. As such, limited data on root diseases was obtained in 2004.

Data from the 2004 OWEYT and OSEYT are attached.

Soft White Winter Wheat Improvement:

Seven soft white winter selections were advanced to USDA Regional Nursery testing for 2005; including OR9801757, OR9901887, ORH010918, ORH010920, OR9901619, OR2010239, and OR2010241. The two selections designated with 'ORH' represent the first of the Hybritech germplasm stocks to reach Regional Nursery testing. ORH010918 and 920 are sister lines from a cross of OSU experimental OR8303765 with a French line designated E81FR. These are from a series of promising Hybritech lines that have high yield potential and short stature and were advanced with the expectations of an agronomic fit for irrigated or high rainfall conditions. OR2010239 and 241 are sister lines from a cross with the variety Cashup. OR9901619 has a parent in common with OR9801757 (OR7946/Hill//Hill) and has very soft kernel texture, similar to OR9801757. Grain yield and performance data for these SWW experimental lines can be found in the attached OWEYT summary.

The soft white winter selection OR9900553, under Breeder seed increase in 2004, was not advanced for 2005. Although it has superior end-use quality and soft kernel texture, similar to OR9801757, OR9900553 was not competitive for grain yields in the 2004 trials. The yields for OR9900553 were most disappointing in WSU Variety trials and at high yields sites where its short-stature should have been an advantage.

Hard White Winter Wheat Improvement:

For the last several years, our hard white wheat breeding efforts have been focused on crosses with Plains hard wheat germplasm. These were needed to improve protein quality and multi-purpose product applications of our hard white germplasm. The first series of F5 lines derived from these crosses were evaluated this past year. They were developed as part of PhD thesis research of Sarah Gehlhar to investigate relationships between protein composition and noodle quality. Although we have limited data, large variations in protein quality were observed among lines, which suggests that we have a good opportunity to identify superior quality types. Many of the lines also have excellent plant type, promising yield potential, and good disease resistance. Ninety two of the most promising hard white lines were advanced to multilocation yield trials for 2005.

OR942496, one of the last promising hard white selections that we inherited from Warren Kronstad, also was dropped from further testing. OR942496 was developed from the spring x winter cross 'CEBECO148//CNO/INIA//LFN/3/K//PET/RAF/4/ ND/P101//AZT'. In 2004, OR942496 was evaluated in USDA Regional nursery trials and in the Asian Products Collaborative. As we suspected, OR942496 performed only marginally in the APC product evaluations because of slightly weak gluten characteristics, soft noodle texture, and intermediate noodle color scores.

There were relatively few elite hard white winter selections evaluated in the 2004 yield trials. This is a reflection of increased selection pressure on our HW germplasm for

improved noodle color and improved protein quality. Three hard white wheat selections were retained in 2005 USDA Regional Nursery testing; including OR953475, OR952577, and OR2010399. However, these were retained only as important parent stocks for our program, with goal to learn more about their adaptation and performance. The selections do not meet the criteria we have established for acceptable HWW quality.

Hard red winter wheat improvement:

Breeding hard red winter wheat varieties is not a priority in our program. Red-seeded segregates are regularly discarded from red x white crosses. However, grower interest in production and marketing of HRW has continued to increase in the PNW. In our evaluations of the Nickerson hard red germplasm, we have identified red-seeded selections that are high yielding and well adapted to PNW environments and production conditions. This past year we identified a small number of the Nickerson hard red selections that also have promising bread quality. We have advanced these to our Hard Wheat Elite trial which is being grown at nine locations in 2005. If trials and quality tests continue to be promising, one of the selections could be advanced relatively quickly for release to Oregon growers. This would also be a more cost effective option as compared to creating an additional breeding effort for developing HRW varieties. However, as these are direct selections, the Nickerson program would be necessarily be involved in determining the most appropriate release mechanism.

Spring Wheat Improvement:

Tolerance to stripe rust was the major focus of the spring wheat breeding effort in 2004. There was an intense epidemic in our nurseries at Hyslop Farm. Lines that had previously been resistant or tolerant to stripe rust succumbed to second or third waves of infection. The nurseries at Pendleton faired better and, under a more moderate infection, the stripe rust reaction of the varieties and experimental lines was as expected. Responses ranged from completely resistant to highly susceptible. At Pendleton the expanded Western Regional hard spring nursery averaged 101 bu/a with the highest yield of 115 bu/s. At Hyslop, the mean was 69 bu/a and highest yield was 95 bu/a.

The Oregon Spring Elite Yield Trial was grown at four locations: Hyslop, Pendleton, Klamath Falls and Madras. Both Hyslop and Pendleton trials were damaged and the yield data is incomplete. There were two Oregon experimental lines evaluated in the trial, OR490230 (HWS) and OR4880189 (HRS). Both lines will be maintained in the breeding program as parent material, but will no longer be candidates for release. Candidates for the 2005 OSEYT have yet to be determined, pending results of end-use quality analyses.

Hybritech germplasm:

Until fall of 2003, the Hybritech stocks were being managed as a parallel breeding effort to our core program. Promising preliminary and advanced lines are now fully merged into common OSU trials. Of the over 2100 Hybritech purelines donated to OSU and first

evaluated in 2001, two lines are entered in Regional Nursery trials and seven are now in the OWEYT. We anticipate one of these will move to Breeder seed increase next fall with potential for release in 2007. Approximately 1/3 of our F5-F8 advanced lines are selections from the Hybritech germplasm. The last of the early generation Hybritech material are now in the F4 generation. This means we have a large headrow nursery and preliminary yield trial yet for 2005 and 2006, but we are nearly complete with merging of early generation Hybritech stocks into our program. Due to high land costs at Hyslop farm, the early generation stocks (F3 bulks and F4 headrows) are all being grown and evaluated at the Rugg's site. In 2004, selection efforts were facilitated by a severe infection of Stripe rust at both Pendleton and Hyslop.

Early Generations and Crossing:

Over 600 soft and hard wheat crosses were made in the field and greenhouse in 2004. A larger proportion of topcrosses were again made to to facilitate introgression of quality traits and disease resistance from red-seeded or unadapted parent lines. Priority parents include French lines that have shown superior yield potential and disease resistance, Plains hard wheats with superior protein quality; and crosses for development of 2-gene CLEARFIELD* selections. The highest priority F2's are being advanced through the greenhouse using modified single seed descent. In total, 36,000+ F2-F5 headrows, 220 space plant F2 populations, and 400+ bulk F2 and F3 populations were evaluated.

End-use Quality:

End-use quality research and development efforts involve extensive collaborations with Dr. Andrew Ross, the OSU Quality Lab, the Wheat Marketing Center, USDA-ARS-Western Wheat Quality Lab, USDA-GIPSA-FGIS, and commercial companies. Resulting data and information are distributed in various forms and are too numerous to summarize here. Reports from major programs, such as the APC, OVA, USWRN, or WQC are distributed directly to cooperators and others in the wheat industry. Support from Craig Morris and the USDA-ARS Western Wheat Quality Lab in evaluating our preliminary and advanced breeding lines is gratefully acknowledged.

Prior to planting this fall, with support of Drs. Andrew Ross and Jae-Bom Ohm, 1822 lines selected from the F3, F4 and F5 segregating populations were prescreened for hardness and polyphenol oxidase activity. Sixteen percent of the soft white selections were eliminated based on high grain hardness using the SKCS machine. A small number of soft white selections also were eliminated due to very high levels of polyphenol oxidase (PPO) activity. Out of the 1237 soft white selections selected, 1050 were advanced into a preliminary yield trial for 2005.

Of the 585 hard white selections that were harvested in 2005, 40% were discarded based on high PPO activity. The assay for PPO is a rapid and inexpensive indicator of noodle color. By quickly eliminating early lines with questionable quality the overall efficiency of the breeding program is improved.

Basic research, collaborations, and student theses:

Relationship of Protein Composition to End-product Functionality of Hard White Wheat. Sarah Gehlhar, PhD, in collaboration with Andrew Ross.
Research objectives are to introduce superior bread-making quality into Oregon germplasm and investigate the relationship between protein composition and end-product quality of bread and noodles. Five segregating populations were developed by crossing two Oregon HWW lines with two hard winter wheat selections from Nebraska. Significant variation was observed in both HMW and LMW composition of the parent lines. The weak gluten characteristics of OR943576 and OR850513-8 were confirmed by presence of HMW alleles 2+12. OR850513-8 was found to carry only 4 HMW alleles. The Nebraska parents carry the 5+10 alleles, which are preferred for bread quality.

Lines were randomly derived from individual F4 plants and then screened to eliminate individuals with red seed coat or high polyphenol oxidase (PPO) activity. Progeny from the OSU x NE hard white wheat populations showed large variation in grain quality, protein composition, and protein quality as based on SDS-Sedimentation volume. Optimal combinations of HMW and LMW proteins for bread and noodle applications have yet to be determined. However, considering the variation observed to-date in agronomic traits, disease resistances, and end-use quality, these HWW populations are expected to be useful in biochemical and molecular mapping of many traits of importance to wheat production and marketing in the Pacific Northwest.

Influence of moisture stress and N on end-use functionality of hard white winter wheat. Carolina St. Pierre, PhD, in collaboration with Andrew Ross.
Hard white varieties and management practices are needed that can produce and deliver grain with consistent protein content and processing quality. A line-source irrigation system was used to investigate interactions of moisture stress and N management on end-use quality of nine varieties grown in 2003 and 2004. Quality analyses have been completed on samples from 2003 and are underway on the 2004 samples. As one might expected, we found that increasing moisture stress resulted in increased grain protein content. However, moisture stress also had a direct influence on protein quality as measured by SDS Sedimentation volume, dough mixing properties, and size-exclusion HPLC. Protein quality improved with increasing stress, as evidenced by higher SDS volume and increased proportion of gliadin proteins. Moisture stress also contributed to higher levels of polyphenol oxidase, which causes discoloration and is deleterious in noodle applications. Preliminary analyses show that varieties do not all respond the same to stress and N. This suggests is may be possible to improve stability of hard white end-use quality through breeding and selection for optimal protein and biochemical compositions.

Improving genetic resistance to Cephalosporium Stripe of wheat through field and toxin screening and molecular mapping with novel genetic stocks. In collaboration with Oscar Riera-Lizarazu and Chris Mundt (funded in part by STEEP).
We have identified promising genetic stocks with superior resistance to Cephalosporium stripe from French varieties and germplasm. However, incorporating genetic resistance

into new wheat cultivars remains difficult due to inconsistencies in expression, environmentally dependent and erratic disease pressures, and inability to effectively screen early generation breeding materials. Four populations, based on single or 3-way crosses of OSU varieties 'Tubbs' and 'Weatherford' with 'Rossini' or 'Rossini' derivatives, have been developed and are now under evaluation. Through combination of inoculated field trials, molecular marker development, and laboratory screening for response to toxins, we expect to develop varieties with superior resistance to this important disease. Availability of molecular markers linked to Cephalosporium stripe resistance also will facilitate rapid screening of breeding materials in absence of the pathogen, saving significant amounts of time, space, and materials.

CLEARFIELD* production system research. In collaboration with Dan Ball.
We are continuing to evaluate tolerance of new CLEARFIELD* wheat varieties to Beyond herbicide. The research has contributed to release of ORCF-101, ORCF-102, and provided important information for growers and seed industry regarding herbicide response and potential crop damage. For 2005 efficacy trials, we have included three CLEARFIELD lines developed by Bob Zemetra at the University of Idaho.

Herbicide tolerance of eight CLEARFIELD* varieties, including ORCF-101 and ORCF-102, were evaluated in 2002, 2003, and 2004 at Pendleton and Moro, Oregon. Beyond™ was applied at two different growth stages using 4, 6, or 12 oz rates in conjunction with a 0.25% non-ionic surfactant and 1% Solution 32 (v/v). In two of the six field trials, all CLEARFIELD* varieties showed significant visual crop response to Beyond herbicide. The response appeared to be related to post-treatment environment conditions and crop health, in addition to application rates. Visual response symptoms did not necessarily translate into reduced grain yields, however. The CLEARFIELD* varieties in this study, including ORCF-102, ORCF-101, Idaho 587, Clearfirst, and CV-9804, responded similarly to varying rates and application dates for Beyond herbicide. As indicated by non-significant treatment by variety interactions, there was no evidence of a genetic background effect on expression of the CLEARFIELD* trait among these varieties with regard to grain yield.

Preferred Variety Lists. In collaboration with Andrew Ross.
Grain samples from the OWEYT and OSEYT are provided to the Western Wheat Quality Lab for use in GxE end-use quality evaluations. Resulting quality data are the basis for Oregon Preferred Variety Lists prepared by Andrew Ross. Our long-term goal is to develop more comprehensive data on variety quality characteristics for use in variety release decisions, marketing information, and preferred variety lists for Oregon growers.

Wheat Pathology. Collaborations in wheat pathology researchers are ongoing. These include research by Dick Smiley to evaluate elite cultivars and novel germplasm for Fusarium foot rot resistance. The 6th year of Fusarium trials are now underway. Chris Mundt is screening elite selections, novel germplasms and resistance genes for reaction to psuedocercosporella footrot and Cephalosporium stripe. In addition, Mundt, Peterson, and Riera-Lizarazu are collaborating on a 3-yr STEEP grant for research on Cephalosporuim stripe in wheat.

International Germplasm Exchange. In collaboration with CIMMYT, Turkey. Our program supports the quarantine increase, packaging, and distribution of seed stocks for the Facultative and Winter Wheat Observation Nursery (FAWWON) and EEWWRYT Eastern Europe Winter Wheat Regional Yield Trials. The stocks are an important source of new parents for our program and are provided to breeding programs throughout the US and North and South America. Grant funds through the US AID-supported Central Asian Caucuses program are to cover our costs for managing the nurseries in 2005.

IMPACTS:

The soft white winter wheat 'Tubbs' was released to growers in 2002. Over 300,000 acres of production are anticipated for 2004. Tubbs represents a significant improvement in grain yield and will provide direct economic returns to Oregon wheat growers through increased productivity and production efficiency. ORCF-101 and ORCF-102, broadly adapted CLEARFIELD* herbicide resistant varieties, will reduce economic losses from grassy weeds, increase management options, and further increase production efficiency. Varieties with enhanced end-use quality, such as OR9801757, are expected to increase market demand for Oregon wheat and may provide the basis for identity preserved marketing. Investments in wheat breeding continue to contribute to the state agricultural economy through increased grain yield, enhanced yield stability, increased production efficiency, superior end-use quality for marketing and novel quality for market development.

RELATION TO OTHER RESEARCH:

OSU wheat breeding and genetics research is conducted in collaboration with many researchers throughout Oregon, the PNW, and the world. Samples from the OWEYT, OSEYT and breeding trials are the basis for the OWC grant-funded end-use quality research of Andrew Ross, the USDA-WWQL and Wheat Marketing Center. Numerous crosses and populations are being developed for collaborative genetic studies on molecular marker development, end-use quality, disease resistance, adaptation, and stress tolerance. These studies involve collaborations with Ross on biochemical bases of end-use quality; with Oscar Riera-Lizarazu on development and applications of molecular markers; with Chris Mundt on laboratory and field evaluations of Cephalosporium stripe and Pseudocercosporella footrot resistance; with Dick Smiley on evaluations of Fusarium crown rot. Herbicide resistant wheat cultivar development and stewardship continues with Dan Ball and BASF. New studies of N management interactions with drought stress and genetic control of protein content in hard white germplasm are being pursued in collaboration with Neil Christensen and Stephen Machado. Germplasm development efforts involve collaborations with Nickerson, CIMMYT, Agripro and many others.

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RELATED PUBLICATIONS AND PRESENTATIONS:

Refereed journal articles

Graybosch, R.A., C.J. Peterson, and O.K. Chung. 2004. Registration of N95L11881 and 97L9521 strong gluten 1BL.1RS wheat germplasms. Crop Science. 44:1490-1491.

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Growing CLEARFIELD Wheat This Year? R. Karow, D. Ball, J. Colquhoun, C. Mallory-Smith, and C.J. Peterson. October, 2004.

Reactions of Foots and Tubbs to Stripe Rust in 2004. X. Chen and C.J. Peterson. September, 2004

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St. Pierre, C., C.J. Peterson, A.S. Ross, J. Ohm, M. Verhoeven. 2004. Influence of moisture stress on N and end-use functionality of hard white wheat. Agronomy Abstracts

Web sites

OSU Wheat Breeding and Variety Performance
http://cropandsoil.oregonstate.edu/wheat/

OSU CLEARFIELD Wheat Varieties - Release, Licensing, Stewardship

http://cropandsoil.oregonstate.edu/wheat/orcf-101/

Variety releases and PVP

'ORCF-102', a CLEARFIELD soft white winter wheat. C.J. Peterson, M. Verhoeven, M. Larson, B. Hoefer, W.E. Kronstad, R. Karow, J. Bassinette, C. Morris, D. Engle, A. Ross, J. Ohm, D. Ball, C. Mundt, R. Smiley, Z. Chen, and G. Vollmer. Released September, 2004.

PVP Certificate No. 200300287 'Tubbs' soft white winter wheat. Received Sept. 2004.

PVP Certificate No. 200300286 'ORCF-101', a CLEARFIELD soft white winter wheat. Received June, 2004.

Presentations – Invited

The Costs of Improving Wheat Quality. PNW Wheat Quality Council, Feb. 3, 2004. Couer d' alene, ID.

Goals for Oregon wheat 2004-2022. OWGL Board of Directors. March 2, 2004. Bend, OR.

Contributions of Breeding to the Oregon Wheat Industry. OSU Council of Regents. June 15.

Wheat breeding at OSU. Walla Walla County WAWG Meeting. Nov. 14. 2004.

OSU variety and breeding update. Video presentation for McGregor company. Dec. 29, 2004.

Presentations - other

OSU Wheat Breeding - Progress Update. OWC Research Review. Feb, 20, 2004. Pendleton, OR.

OSU Seed Associate Meeting. Update on performance, commercialization, and licensing of OSU's Clearfield varieties ORCF-101 and OR2010007. June 15, 2004, Pendleton, OR. OSU Crop and Soil Science. Host, speaker, and organizer of the ½ day meeting.

Wheat varieties and stripe rust update for the Willamette Valley. Sept. 2, Salem, OR

Proposal for release and semi-exclusive licensing of OR9801757. Oregon Wheat Industry Convention. Dec. 6, 2004. Tigard, OR.