

**Title:** Development of wheat varieties adapted to Oregon with improved disease resistance, stress tolerance, and superior end-use properties

**Principal investigator:** C. James Peterson

**Goal:** Improve profitability and sustainability of wheat production in Oregon.

**Research areas:** Wheat breeding, genetics, grain yield stability, disease and insect resistance, drought and heat tolerance, winterhardiness, end-use quality, and value-added traits

**Objectives:**

1. Develop and release new wheat varieties with superior disease and insect resistance and enhanced tolerance to abiotic stresses that minimize production risks, increase economic returns to growers, and promote adoption of farming practices that enhance environmental quality
2. 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.
3. 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.
4. Develop public-private partnerships as means to access and deliver new technologies to our growers. Contribute to risk assessment and technology stewardship programs for new biotechnologies.

**Introduction and Justification:**

Wheat is the major cereal crop for Oregon with annual production averaging over 55 million bushels/year and gross value of over \$200 million/year at the farm-gate. Investments in wheat breeding have provided tremendous economic returns to Oregon growers through deployment and production of improved wheat varieties. For example, from 1984 through 2000 Oregon grain yields averaged 60.7 bu/a. This represents a 45% increase in yield compared with the period 1969 to 1979, when state production averaged 41.8 bu/a. Modern high yielding soft white wheat varieties, such as Stephens,

Gene, Madsen and others released in the late 1970's and '80's, are responsible for approximately 2/3 of this yield increase (Peterson et al., 2001; Peterson, 2002).

Even with the many contributions from OSU wheat research efforts to date, tremendous challenges still confront our growers. Production costs and risks continue to escalate while the rate of yield increase from variety development efforts appears to have declined. Management practices are changing and evolving in attempts to improve environmental stewardship, production sustainability and profitability. Drought and temperature stresses continue to limit grain yields and we are experiencing increasingly erratic weather patterns. Disease and insect pressures are increasing and evolving in response to varieties and changing management and environmental conditions. The world grain market is increasingly sophisticated and competitive, placing increased demands on wheat end-use quality. Further improvements in yield potential, yield stability, disease resistance and stress tolerance, and end-use quality are needed to sustain and improve economic viability of Oregon wheat producers.

Oregon exports approximately 85% of its wheat production each year, primarily to countries of the Pacific Rim and Middle East. The Pacific Northwest produces high quality grain, but that grain is marketed as a generic commodity using a U.S. Grain Classification system that has little relationship to processing value and product functionality. Demand for soft white wheat, the dominant market class of the PNW, has declined, while market interest and opportunities in hard white wheat have grown (John Oades, US Wheat Associates). Asian countries import 1 billion bushels of wheat each year, 50% of which is consumed in the form of noodle products. Noodle consumption continues to increase. Australian white wheats, particularly Australian Standard White or Prime Hard classes, have been preferred for producing the highest quality noodle flours. Development and release of superior hard white wheat varieties is needed if our growers are to remain competitive in the Asian markets. Segregation, identity preservation, and partnerships for vertically integrated marketing are viewed as industry priorities to enhance competitiveness and become more responsive to our customer needs. For the OSU breeding program, this means we must develop and identify varieties that offer improved functionality, product specific quality and value-added quality traits if we are to remain competitive and increase market demand for Oregon wheat.

## **Research Procedures and Approaches**

**Objective 1:** Develop and release new wheat varieties with superior disease and insect resistance and enhanced tolerance to abiotic stresses that minimize production risks, increase economic returns to growers, and promote adoption of farming practices that enhance environmental quality

**Current status:** Faced with highly variable production conditions and constraints in the Pacific Northwest, Dr. Warren Kronstad (former OSU Wheat Breeder, now deceased) developed a broadly adapted, high-yielding germplasm base using a modified shuttle-breeding approach (Peterson, 2002). The Hyslop Agronomy Farm in Corvallis was used for early generation selection under high yield, high rainfall conditions with significant foliar disease pressures. The Rugg-Barnett site

near Pendleton provided a high-yield, dryland, and intermediate rainfall site with minimal foliar disease pressures other than Stripe rust (*Puccinia striiformis*, Westend.). A third site, at Sherman County Experiment Station in Moro, provided for adaptation under very low rainfall conditions and significant soil disease pressures. These three sites provide very different biotic and abiotic stresses associated with wheat production. The approach was proven very effective in establishing broad adaptation in the OSU germplasm base, as evidenced by success of varieties such as Stephens, which have been widely grown throughout the PNW.

The opportunity exists to increase grain yields and build on this broadly adapted germplasm base by incorporating genes, traits, and selection strategies that exploit components of 'specific' adaptation. That is, to develop genetic combinations that can exploit the unique production conditions or constraints within each of the major agroecological zones of the PNW. Cropping systems and management practices continue to evolve in response to economics, sustainability and environmental issues. However, there has been little effort to consider or exploit potential interactions of genotype with management practices in variety breeding efforts (Allan and Peterson, 1987). Growers are increasingly using high residue or direct seed practices to minimize soil erosion and moisture loss, but these same practices result in increased disease pressures and environmental stresses on the wheat crop. Breeding for high residue management situations will require renewed commitment and partnerships to improve genetic resistance to a wide array of stresses and diseases (Hwu and Allan, 1992). Research efforts will address root disease complexes that limit yields under dryland cropping systems; such as Cephalosporium Stripe (*Cephalosporium gramineum*, Nis& Ika), Fusarium dryland footrot (*Fusarium* spp.) , Rhizoctonia sharp eyespot (*Rhizoctonia cerealis* Van der hoeven) and Strawbreaker footrot (*Psuedocercospora herpotrichoides* (Fron) Deighton) diseases.

**Approach:** Wheat germplasm will be evaluated under an array of environments and management practices to characterize performance and response to biotic and abiotic stresses. Early generation stocks (F1 through F5) will be evaluated through a shuttle between Hyslop and Pendleton to identify broadly adapted, disease resistant selections with high yield potential. Multi-site evaluation of mid-generation materials (F5 and F6 preliminary lines through F9 advanced selections) will then be conducted to rapidly identify lines with both broad and specific adaptation, determine response to multiple disease complexes and pressures, and develop varieties that are targeted for specific management practices or constraints.

In addition to core breeding sites at Hyslop, Moro (Sherman County Experiment Station), and Ruggs, five 'satellite' test sites will evaluate genetic response to a wide array of production conditions. In fall 2001, satellite test sites were planted near Moro, Condon, Arlington, Pilot Rock, and Hermiston. These sites were

chosen to represent a diverse array of production conditions; from very low rainfall to full irrigation, shallow to deep soils, and low residue to high residue management practices. Each 'satellite' nursery will consist of replicated yield trials of hard and soft white elite lines (70 to 120 entries) and an unreplicated observation nursery of short rows (approximately 450+ entries). The observation nursery will include rows of all preliminary (F6) and advanced (F7 through F9) breeding lines and promising parental stocks for visual scoring of plant type, vigor, disease reactions, stress tolerance, and finish. This is a cost-effective means to gain information on adaptation and stress tolerance of early generation lines without the high seed requirements and expense associated with management of full-size plots. The replicated yield trial included at each site will provide valuable data on yield stability, range of adaptation, and disease resistance of elite lines nearing release. It also provides grain samples to evaluate stability and consistency of end-use quality traits.

Wheat acreage planted through direct-seedings (no-till) continues to increase in the Pacific Northwest. Although the major PNW varieties have been periodically evaluated under direct-seed conditions, there has been little effort to develop or identify new varieties adapted to direct-seed management practices. In fall, 2000, a direct-seed research nursery site was established at the Sherman County Experiment Station in collaboration with Don Wysocki, Erhling Jacobsen, and Russ Karow. The nursery includes the Statewide Variety Trial and our Elite Nurseries to characterize performance of both current varieties and our most advanced breeding lines. In addition, we are evaluating a diverse set of F2 populations for their potential adaptation to direct-seed conditions. If the trial is successful in differentiating varietal response, we will initiate selection from within the F2 populations and consider options for additional direct-seed evaluations and/or breeding efforts.

**Objective 2:** 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.

**Current Status:** Improving quality of soft white winter wheat varieties for use in cakes and cookies has long been an important goal of the OSU breeding program. In collaborations with the ARS-Western Wheat Quality Laboratory, breeding materials are routinely evaluated for protein content and grain quality, milling properties, dough handling, cookie diameter and sponge cake volume. Historical standards for soft wheat quality must be met, or exceeded, before a new variety may be released into the marketplace (Eskridge et al., 1994). However, soft white wheat, the predominant quality class grown in the PNW, is marketed as a generic commodity, with little regard to product functionality once grain has left the farm. The challenge now is to capture value from end-use quality research efforts and find means to define, develop, diversify, and deliver quality, value, and functionality to our customers.

There is tremendous genetic diversity in proteins, starches, and mechanical processing attributes that can be exploited to improve product-specific qualities as desired by our premium customers (Peterson et al., 1997; Graybosch et al., 1996). We are currently exploring an array of strategies to segment and diversify the wheat market of the Pacific Northwest. One such strategy is to develop 'quality-subclasses', or 'branding', within the more generic class structure of the U.S. Grain Classification system. Ideally, these subclasses would be based on end-use functionality and product applications. Hard white wheat development will continue as an important goal in collaboration with the Wheat Marketing Center, as we address quality needs and opportunities in the Asian markets. Multi-product functionality of hard white wheat is a priority, with the expectation that hard white wheat will be segregated and marketed on grain protein basis. PNW-grown hard white varieties must make acceptable pan-breads at high grain protein levels, acceptable raw noodle products at intermediate protein levels, and acceptable steam breads at lower protein levels. Defining and delivering quality subclasses within the Soft White class will be more challenging. Segregation of soft white wheat on grain protein content is fairly common and the practice is increasing. However, there also are emerging opportunities for identity preserved marketing of very soft texture lines with superior cookie qualities, varieties with improved protein quality for use in flat breads, and varieties with partial waxy starches for noodle markets, not to mention the ongoing need to improve soft white wheat quality just to remain competitive in the international marketplace.

Understanding of biochemical components and interactions that effect end-use processing attributes and product textural qualities are needed to effectively design and develop value-added and enhanced quality varieties (Graybosch et al., 1990; Graybosch et al., 1994; Primard et al., 1991). The role and magnitude of environmental effects (Blumenthal et al., 1993) and genotype by environment interactions for key quality traits also must be considered in variety development and marketing strategies (Bassett et al., 1989; Peterson et al., 1992; Rao et al., 1993). Close communication with our customers, with producers, the grain trade, and milling companies also will be critical if we are to make significant changes in how the U.S. produces and markets wheat and capture value from enhanced end-use quality.

**Approach:** Soft white winter wheat improvement will continue to be the primary focus in the breeding program, accounting for approximately 60% of the program effort. Improving soft white quality for cookies and cakes remains a high priority, with focus on germplasm with extra-soft texture, high milling yields, low pentosan concentrations, and low PPO activity. The remaining 40% of our efforts will be allocated to quality improvement for 'end-use market development'. This includes hard white winter wheat development for Asian noodle products and development of hard and soft wheats with value-added quality traits, such as extra-soft, low-amylose, or waxy starch wheats. Hard white wheat development

will focus on quality and applications in Asian noodle products and steam breads. As suitability for dual- or multi-purpose product applications appears critical for hard white wheat marketing, we are striving to identify and develop materials with improved hardness, protein quality, and bread making ability.

A wide array of genetic stocks are being utilized in the program to generate progeny with diverse protein and starch characteristics and enhanced product color; including strong-gluten hard red germplasm from the Midwest; waxy germplasm stocks from USDA-ARS; Australian hard white wheat varieties; hard spring wheat germplasm from CIMMYT; and soft white wheat cultivars from throughout the PNW. Grain samples from a wide array of production environments will be used to characterize varietal stability, influences of environment, and interactions of genotype x environment on processing and product quality.

Relationships between protein quality, composition, and bread-making attributes have long been a focus of cereal chemistry investigations. While optimal HMW subunit and protein composition has been identified for leavened bread products (Lukow et al., 1989; Payne et al., 1984; Payne et al., 1987; Payne et al., 1988), little is known about the influence of protein composition on quality of Asian noodle products. Protein quality of parents, advanced lines, and segregating materials will be measured using an array of methodologies, including from HMW subunit composition, size-exclusion RP-HPLC (Marchylo et al., 1989), and SDS-Sedimentation volume. Of particular interest in our program is the influence of starch composition on the often-subtle texture properties required for making acceptable Asian noodle products and steam breads. Granule bound starch synthase genes have been identified that produce 'partial waxy' endosperm traits in wheat (Nakamura et al., 1992; Nakamura et al., 1993). There are three possible forms of partial waxy mutants, combinations of which appear to contribute enhanced noodle properties by increasing the amylopectin/amylose ratio in starch.

Superior end-product color, particularly in noodle products, is critical for wheat varieties being marketed into Asia. The enzyme Polyphenol Oxidase (PPO) has been long been associated with discoloration of fruit during storage. High levels of PPO in flour have also been associated with the phenomena of noodle discoloration after processing (Kruger et al., 1992; Kruger et al., 1994). U.S. hard white wheat breeding programs, including our own, are utilizing a simple tyrosine or L-Dopa-based color assay for PPO activity. These preliminary tests have established that substantial genetic variation for PPO activity exists. The impact of environment on PPO activity is less clear, however, as is important of genotype and environment interactions. Addressing environmental stability of low PPO activity in hard white varieties and identifying biochemical causes of secondary browning will be important to establish consistent and superior noodle quality.

The Federal Grain Inspection Service currently classifies hard white wheat varieties based on ability of grain to meet an arbitrary visual 'color line' and kernel morphology expected for a hard-grained red wheat. The color line was established using a grain sample from the hard white variety 'Klasic' produced in California. Research on hard white wheats grown in the Great Plains suggests it will be difficult to consistently achieve an arbitrary grain color standard (Peterson et al., 2001). In addition, the PNW environment is naturally conducive to producing grain of larger kernel size and lower protein content, which will make it more difficult to visually distinguish hard and soft wheat samples. Several techniques are being investigated to more objectively assess seed color, including scanning NIR, Minolta color meters, alkaline stain tests, and other wet chemistry approaches. Objective color tests will be developed and implemented into hard white selection strategies as possible. Samples of promising hard white lines grown at multiple locations will be submitted to FGIS each year to confirm classifications and compare visual classification information with objective tests.

Integration of plant breeding and genetics, molecular genetics, statistical, biochemical, and cereal chemistry expertise will be needed to effectively identify, develop, and exploit variation in wheat end-use quality needed for marketing. This project is in a unique position to address quality research and development needs through multi-disciplinary and multi-product approaches. Collaborations with Andrew Ross, OSU Cereal Chemist; Craig Morris, Director, USDA-ARS Western Wheat Quality Laboratory; Dave Shelton, Director, Wheat Marketing Center; Oscar Riera-Lizarazu, OSU Molecular Geneticist and others, allow for field oriented genetic and breeding studies to be combined with biochemical techniques such as SDS gel electrophoresis, size exclusion HPLC, ELISA, and PCR marker technologies and milling, dough handling, and baking evaluations. This approach will result in new selection methodologies and laboratory techniques, provide basic research information, release of unique varieties and germplasms, and effectively translate research efforts to grower and market impact.

**Objective 3:** 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.

**Current Status:** Varieties with improved resistance to major diseases of the Pacific Northwest, such as *Pseudocercospora* (McMillan et al., 1986), *Cephalosporium* stripe (Roberts and Allan, 1990), bunts (Mathur and Cunfer, 1993), stripe and leaf rust (Line and Qayoum, 1991), *Septoria*, and various dryland rootrots are needed to ensure stable yields and produce a superior quality wheat crop. Genetic resistance, when available, remains the most environmentally sound and cost effective means of disease control. However, this requires an on-going supply of new and more effective resistance genes and effective screening strategies to introgress these genes into adapted varieties.

Disease research trials are needed to routinely evaluate response of promising germplasm introductions, new genetic stocks, synthetic wheats and their

derivatives, and mapping populations for derivation of molecular markers. Preliminary disease evaluations have provided us with exciting new leads for improving genetic resistances to Cephalosporium Stripe, Septoria tritici, and dryland footrots diseases. Synthetic wheats and their derivatives, which possess novel genes for disease resistance and stress tolerance from related grass species (Friebe et al., 1996), are similarly playing an important role in our breeding strategies for high residue and direct-seed management situations.

**Approach:** A wide array of germplasms are being used for improvement of disease resistances, including genetic stocks from CIMMYT, western and eastern European breeding programs, and programs from throughout the U.S. In addition, we are introgressing new genetic stocks developed through wide-hybridization that carry novel genes for disease resistance. These include genetic stocks developed by CIMMYT and the ARS program at Manhattan, KS, with leaf disease resistance genes from *T. tauschii*, *T. monococcum*, and *T. timopheevii*. However, we anticipate extensive backcrossing and applications of molecular marker technology will be needed to effectively transfer and utilize many of these novel genes.

In collaborations with OSU Pathologist Chris Mundt, we are evaluating advanced breeding lines and parent stocks for reaction to Cephalosporium stripe and Pseudocercospora footrot in inoculated field trials. Similarly, in collaboration with OSU Pathologist Dick Smiley, inoculated field trials have been established to characterize response of varieties and germplasms to Fusarium dryland rootrot. In addition to screening information for breeding materials, the trials will provide important information on potential effectiveness of various genetic resources with possible resistances and/or tolerances to these diseases.

In collaborative research with OSU Cereal Biotechnologist Oscar Riera-Lizarazu and Chris Mundt, introgression of resistance to Cephalosporium stripe is a high priority for the program. It is also a priority for identification of molecular markers and understanding of the genetic basis for disease response. Several segregating populations, currently in F2, F3 or F4 generations, are being developed for genetic studies and marker development efforts.

OSU contributions to international germplasm development and exchange continue, most evident through our ongoing collaborations with CIMMYT, through our supporting role in distribution of CIMMYT international nurseries, and through direct exchanges with our many close friends and colleagues throughout the world. This past year, our project distributed germplasm in the CIMMYT Facultative and Winter Wheat Observation Nursery (FAWWON) and Eastern European Winter Wheat Regional Yield Trials (EEWWYRT) to wheat breeding programs throughout North and South American, in support of the CIMMYT winter wheat research effort in Turkey.

**Objective 4:** Develop public-private partnerships as means to access and deliver new technologies to our growers. Contribute to risk assessment and technology stewardship programs for new biotechnologies.

**Current Status:** Public wheat breeding programs still dominate variety development efforts in the U.S. However, expectations and the role of public research programs are changing as private investments and advancements in biotechnology continue to grow. The measures of success now are economic impact and contributions to technology transfer. Land-grant universities are looking toward public-private partnerships to access new technologies, to provide funding for new research efforts, provide growers with novel genes and value-added traits, and to participate in commercialization of biotech products. These partnerships also will be important to establishing value-added and identity preserved marketing. Universities such as OSU are struggling, however, with the associated intellectual property rights issues, technology licensing, and the exclusivity and confidentiality requirements of private industry.

**Approach:** We are actively pursuing public-private partnerships as means to bring new technologies to our growers. The first such collaboration using proprietary technologies involves development and release of herbicide resistant soft white wheat varieties. Herbicide resistant varieties will provide growers with new management options for chemical control of grassy weeds, particularly for goatgrass, which is more problematic due to its close genetic relationship to common wheat. In the development of any herbicide resistant variety, an array of issues will need to be considered, such as: levels of herbicide tolerance needed for commercial production; influence of genetic background on expression of herbicide resistance; influence of environment on herbicide resistance and genetic response; technology stewardship and best integrated management practices; and development of herbicide resistant weed populations. Studies evaluating herbicide efficacy and interactions with genetic background are underway in cooperation with OSU Weed Scientists Dan Ball and Carol Mallory-Smith.

Public involvement and research contributions in risk assessment and technology stewardship are important as means to gain consumer acceptance of new biotechnologies. For the University, choice of partners and technologies is critical, as the legal and intellectual property rights issues will impact variety development efforts for decades to come. New approaches will be required to effectively manage public-developed intellectual properties and new measures of accountability will be required as we pursue public-private collaborations. In evaluating opportunities and economic benefits of public-private partnerships, serving the interests of our growers remains our first priority. Growers and industry representatives will be involved in strategic planning, decision- and policy-making discussions and variety release decisions. Our fundamental commitment to free germplasm exchange, as the foundation for all wheat improvement efforts, remains unchanged.

## **Related Activities:**

The OSU Wheat Breeding program was presented with a unique opportunity in fall 2000 when Monsanto donated wheat germplasm stocks from their PNW based HybriTech program to OSU (Peterson, 2001). From 1993 through 1999, HybriTech developed an aggressive hybrid wheat breeding program targeted for the Pacific Northwest. In September 1999, Monsanto closed all their U.S. hybrid wheat breeding efforts, including the Boise-based program. Monsanto donated the HybriTech PNW germplasm to OSU in recognition of the public value of the wheat germplasm base and of OSU's contributions to its development through germplasm exchange. The donation, which essentially doubled the size of the OSU breeding program in 2001, presented an opportunity to access novel genetic stocks and advanced breeding lines for direct use in public variety development efforts for the PNW. The stocks also present a unique opportunity to identify germplasms with exceptional combining abilities based on performance of inbred lines in hybrid combinations and of progeny performance from segregating populations.

We anticipate it will take three years of evaluation and selection efforts before the HybriTech stocks will be fully integrated into our breeding program. Included in the HybriTech stocks were 676 F1 crosses, 920 hybrids, 1331 segregating bulk populations, over 2000 inbred lines, and nearly 600 populations of headrows. While OSU is the primary recipient and owner of the stocks, our intent is to manage the germplasm as a public resource, such that public research programs and growers throughout the PNW benefit from access and use of materials developed through HybriTech's breeding efforts.

## **Benefits to Agriculture:**

Wheat is a major crop for Oregon with annual production averaging over 55 million bushels/year and gross value of over \$200 million/year at the farm-gate. Investments in wheat breeding have provided tremendous economic returns to Oregon growers through deployment and production of improved wheat varieties. From 1969 to 1979, state grain yields averaged 41.8 bu/a. From 1984 through 2000, state grain yields averaged 60.7 bu/a; a 45% increase in yields over the earlier period. Modern high yielding soft white wheat varieties, such as Stephens, Gene, Madsen and others released in the late 1970's and '80's, are largely responsible for this increase. On a production base of 900,000 acres, this translates to a production increase of over 17 million bushels per year or, at \$3.50/bu wheat, an increase of \$59 million per year in farm-gate returns to Oregon growers as compared with pre-1980 production levels. Contributions of improved varieties to yield-maintenance also are critical in the face of ever-changing pathogens and increasingly variable environmental stresses. Previous estimates have suggested that 5 bu/a of current yields, or 4,500,000 bushels on 900,000 acres, can be attributed to yield-maintenance aspects of the OSU cereals breeding, genetics and pathology research efforts. Based on yield trend analyses in similar production areas, the OSU Wheat Breeding program can claim responsibility for

at least 50% of yield-maintenance results (0.5 x 5 bu/a) and 67% of increases in average grain yields (0.67 x 19 bu/a). As such, this project is responsible for approximately 15 bu/a increase in grain yields since 1969; or, 15 bu/a x 900,000 acres x \$3.50/bu = \$47 million per year increase over 1969 production levels. Using 2001 research funding levels and contrasts in production levels between 1969 and 2000, we estimate that for every \$1 invested in OSU wheat breeding program by the state Legislature and Oregon Wheat Commission, nearly \$100 has been returned directly to Oregon growers. The economic contributions of improved varieties go far beyond the farm, impacting seed, fertilizer, chemical and equipment dealers, grain handlers, exporters, millers, bakers, and consumers throughout the Northwest.

Further improvements in yield potential, yield stability, disease resistance and stress tolerance, and end-use quality are needed to sustain and improve economic viability of Oregon wheat producers. Addressing management-specific and site-specific production constraints through enhanced testing of early generation breeding materials and new genetic stocks will result in more rapid genetic improvements and contribute to long-term profitability of Oregon wheat producers. New research efforts to develop value-added, superior quality varieties will further increase demand for Oregon wheat and provide new marketing opportunities for Oregon growers.

### **Funding:**

The Oregon Agricultural Experiment Station provides PI salary, salary for 2.75 FRA, and operating funds. Wheat growers of Oregon support the program through check-off funds administered by the Oregon Wheat Commission. Through the Warren E. Kronstad Endowed Chair for Wheat Research, currently awarded to the Principal Investigator, funds are available for program enhancement and support of breeding efforts. Industry partners have supported the program, but on a more irregular basis. Additional funding opportunities have been, and will be, pursued as they become available, including those from organizations such as STEEP, USDA-NRI, and others.

### **Personnel:**

C. James Peterson, Professor (90% research, 10% teaching)  
Mary Verhoeven, Instructor  
Mark Larson, Faculty Research Associate  
Bruce Hoefer, Faculty Research Associate  
TBA, Faculty Research Associate  
Susan Wheeler, Clerical support  
Student and hourly workers

### **Institutional Units:**

Dept. of Crop and Soil Science, Agricultural Experiment Station,  
College of Agricultural Sciences, Oregon State University

## **Facilities and Equipment:**

Physical facilities and project equipment are adequate to accomplish program goals. A greenhouse is currently used by the project for crossing and seed increase purposes. Adequate plot land and seed processing space is available locally at Hyslop farm. Field and seed processing equipment, including combines, drills, sprayers, tractors, cleaners, threshers, etc. are available and adequate. Laboratory equipment is adequate for routine analyses needs, such as hardness, protein content and quality, dough mixing, starch properties, etc. We will soon have ability to conduct full baking and biochemical evaluations in-house as the new OSU Cereal Chemistry laboratory becomes equipped. Primary work areas include the following:

Crop Science Building: offices and quality laboratory space

OSU Greenhouse Complex: Growth chambers and greenhouse space

Hyslop Agronomy farm: Plot land and laboratory space for seed processing

Field research sites: Sherman County Experiment Station (Moro) and sites with grower cooperators throughout the state

## **Cooperators:**

Collaborations in end-use quality research and testing are critical to success of OSU variety development efforts. Long-standing collaborations and support from the USDA-ARS Western Wheat Quality Lab are responsible for capturing and maintaining soft wheat quality attributes needed in varieties destined for the export market.

Collaborations with the Wheat Marketing Center on Asian noodle evaluations have contributed to our understanding of hard white wheat development and have led to release of the first OSU hard white spring wheat variety, 'Winsome'. Andrew Ross, the new OSU Cereal Chemist, brings critical expertise and new collaborative research opportunities in the biochemistry and genetics of wheat and flour for use in Asian products. Using a vertically integrated approach, from biochemistry of proteins and starches through product evaluation to variety release, we anticipate release of both hard and soft wheats with novel end-use qualities, providing growers with new choices for marketing and market development.

OSU wheat variety development and genetics research is conducted in collaboration with OSU faculty in Crops, Soils, Extension, and Plant Pathology throughout the state. Our collaborations on germplasm development, evaluation, and genetics research extend throughout the tri-state region and U.S., including collaborations with major private companies and public researchers at the University of Idaho, USDA-ARS, and Washington State University. Examples of which include commitment to USDA-ARS Regional Nursery programs; our ongoing commitment to regional and international germplasm exchange; collaborations in germplasm evaluation and exchange with several private companies; tri-state nurseries for collaborative evaluation of spring wheat germplasm; and collaborations with U of I breeders to evaluate winter wheat germplasm for irrigated production. The historically close working relationship between OSU and CIMMYT continues through germplasm exchange, collaborative germplasm development, and through OSU support and distribution of CIMMYT international winter

wheat nurseries; such as the Facultative and Winter Wheat Observation Nursery (FAWWON) and Eastern European Winter Wheat Regional Yield Trial (EEWWRYT).

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