

# 2009

# Dryland Field Day Abstracts

## Highlights of Research Progress

TIMELY SOLUTIONS FOR SHIFTING ECONOMICS

WASHINGTON STATE UNIVERSITY  
 EXTENSION

Department of Crop and Soil Sciences  
Technical Report 09-1

WSU Dryland Research Station Field Day  
Lind June 18, 2009

WSU Cook Agronomy Farm Field Day  
Pullman June 25, 2009

WSU Spillman Agronomy Farm Field Day  
Pullman July 9, 2009

*Dedicated to Dr. Douglas L. Young*



## *Welcome to our 2009 Field Days!*

*2009 Dryland Field Day  
Abstracts: Highlights of  
Research Progress*

*Technical Report 09-1*

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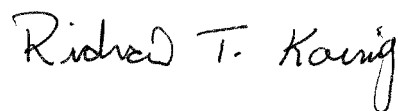
As Chair of the Department of Crop and Soil Sciences, I am proud to introduce the *2009 Dryland Field Day Abstracts: Highlights of Research Progress*. This publication has a simple purpose: to introduce you to numerous research projects conducted in 2009 by WSU faculty and USDA-ARS research scientists working as part of, or in cooperation with, the Department of Crop and Soil Sciences.

Our theme this year is “Timely Solutions for Shifting Economics” and this publication is dedicated to the long-time service of Dr. Douglas L. Young, agricultural economist, who retires in 2009.

The Department of Crop and Soil Science vision states “We discover and develop principles of crop and soil sciences through scientific investigation and apply these principles to the development of new crop varieties and new crop, soil and water management practices in agricultural, urban and natural environments; teach principles and applications to undergraduate and graduate students; provide experiential learning opportunities for students to work with world-class faculty; promote diversity of ideas, people, cultures; disseminate accumulated knowledge through resident instruction, continuing education, Extension, publications, and professional contacts.” The mission statement underscores the well-balanced programs across the tripartite mission of the land grant institution in academic programs, research and extension, and the balance and interrelationship between scientific principles and application in all three endeavors.

As you will note while reading the enclosed abstracts, we are engaged in many research activities of regional and national prominence. Our 2009 departmental sponsored field days are just one way for us to help you learn more about the latest developments in our research programs.

Sincerely,



Dr. Richard T. Koenig, Chair  
Department of Crop & Soil Sciences



**Cover photo:** ‘Cara’ soft white winter wheat at St. John, Washington. Released by the USDA-ARS in 2007 for the intermediate to high rainfall region. Cara has competitive grain yield, excellent disease resistance and superior club wheat quality.

Photo by Kim Campbell.





## Dedicated to Dr. Douglas L. Young

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Dr. Douglas L. Young, agricultural economist at Washington State University, is retiring this spring after 32 years of service.

Doug grew up on a remote ranch in northeastern Oregon. He began his education in a one-room country school and completed his elementary and high school education in Joseph, Oregon. He began driving tractors at age 11 and enjoyed skipping school for two weeks each spring to help his Dad put crops in. After earning a B.A. in economics at the University of Oregon, Doug spent two years as a Peace Corps volunteer in Kenya on a livestock and range development project. He conducted productivity surveys of thousands of cattle, camels, sheep, and goats. A high point of his Kenya experience was meeting his future wife on a blind date in Nairobi. Lillian was working as an elementary teacher with the Norwegian Volunteer Service. During his Ph.D. in agricultural economics at Oregon State University, Doug worked 18 months on a USAID/OSU weed control/cropping systems project in northeast Brazil. Doug's interest in multidisciplinary research took root early. In Kenya he worked with range ecologists, animal scientists and wildlife biologists; while in Brazil he worked with crop scientists, weed control specialists, and soil scientists among others.



Doug joined the faculty of the Department of Agricultural Economics at WSU in November, 1976. Doug enjoyed teaching throughout his career, especially undergraduate advanced farm and ranch management and international agricultural development, and a graduate agricultural production economics course. He twice was a College of Agricultural, Human, and Natural Resource Sciences R.M. Wade featured teacher.

Doug always took the agricultural adjective in agricultural economics seriously. He believed that joining quality agricultural science and economic analysis produced more cost effective solutions to agricultural and environmental problems. Doug did research in agricultural risk management, pest management, sustainable agriculture, resource conservation practices and policy, commodity policy, biofuels, benefits of new agricultural technology, and the payoff from resource conservation. He contributed to the administrative leadership of several College and multi-state projects including the USDA-STEEP project, the IPM Cropping Systems project, the Air Quality project, and others.

As a measure of his involvement in Department of Crop and Soil Sciences research, Doug authored or coauthored 62 abstracts and/or articles for the annual *Dryland Field Day Abstracts/Proceedings: Highlights of Research Progress* over the past two decades. These represented 86% of contributions to this bulletin by economist authors. Most of these abstracts and articles were coauthored by Doug's crop and soil science collaborators and his graduate students. Doug served as major professor for 39 graduate students at WSU and on committees for many others, including students from Crop and Soil Sciences, Biosystems Engineering, and Political Science. He has published many book chapters and a large number of journal articles in both top agricultural economics and agricultural science journals.

Doug has been active in professional and public service. He has served as president of the Western Agricultural Economics Association (WAEA), editor of the *Western Journal of Agricultural Economics*, a member of two journal editorial boards, a witness to the U.S. Congress, a member of a National Academy of Science/National Research Council panel, and a visiting scholar at universities in British Columbia, Alberta, and North Carolina. He has been a long time member of the Washington State Advisory Committee of the Natural Resources Conservation Service. He is a Distinguished Scholar of the WAEA and recipient of other research and extension awards.

Most rewarding in Doug's career has been the friendship and mutual trust he has accumulated among colleagues from various disciplines at regional universities, USDA-ARS, with graduate students, and among many farmers and ranchers in the Pacific Northwest. He will continue these relationships as he and Lillian will retire in Pullman. Doug plans to continue to work as an agricultural economics consultant as time away from Lillian, grandchildren, and fishing streams permit.

## Conservation Tillage Research and Adoption in the Pacific Northwest

*Invited commentary by Dr. Douglas L. Young*

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A great source of satisfaction during my 32 years at WSU has been the opportunity to work with talented agricultural and social scientists committed to developing profitable cropping systems to enhance soil, water, and air quality for Pacific Northwest (PNW) farmers. This satisfaction reflects my belief that solving societal problems requires cooperation among many disciplines. Farmers and other citizens often complain that academic disciplinary research is too often “an inch wide and a mile deep.” A broad perspective on resource conservation research and extension in the PNW was pioneered by Soil Conservation Service employee, Verle Kaiser, and Pullman USDA/ERS agricultural economist, Walter Pawson. These men worked to quantify the effects of erosion on crop productivity and economic returns after World War II until the 1970's. Early farmer-inventors like Mort Swanson, and agricultural engineers including Charles Peterson and Keith Saxton, among others, improved stand establishment and yields by developing direct-seed drills with improved fertilizer and seed placement. Alex Ogg, Frank Young, Donn Thill, and others developed improved systems approaches for controlling weeds in direct seeded small grains and legumes. *Fusarium*, *Pythium*, and *Rhizoctonia* root diseases are a major problem in direct seeded wheat grown continuously or in two-year rotations. Plant pathologists—including James Cook, George Bruehl, Richard Smiley, Tim Murray, Tim Paulitz, and others—developed diverse rotations, tillage to eliminate the “green bridge,” and other methods for reducing these diseases in direct seed and conservation tillage systems. Several PNW crop breeders developed more disease resistant varieties.

My early involvement in this research was enlisted by Bob Papendick who brought an untiring commitment and strong leadership to multidisciplinary research in the STEEP, Columbia Plateau PM<sub>10</sub>, IPM Cropping Systems, and other PNW conservation projects. An early successful multidisciplinary direct seed project was the Pullman-based IPM cropping systems project led by Frank Young during 1986-94. A direct seed winter wheat/min-till spring barley/min-till spring pea rotation with appropriate chemical weed control effectively managed weeds, diseases, and soil compaction. Farmers were pleased with the system's high average profit and relatively low level of profit risk over time. The win-win relationship between profit and risk contrasts with the typical pattern of financial investments where portfolios with higher average returns typically incur higher risk. Furthermore, this system satisfied residue and acreage requirements of the 1985 and subsequent Farm Bills.

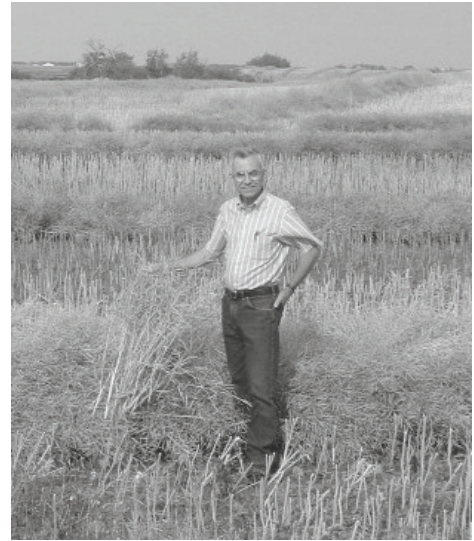
Turning to the lower rainfall wheat-fallow areas of the PNW, annual no-till spring cropping is an unqualified environmental success. Engineering modeling has shown that these systems can reduce predicted dust emissions by 94% during severe wind events compared to winter wheat-tillage summer fallow (WW/TSF). But my economic evaluations of long-term no-till annual spring cropping experiments by Bill Schillinger at Ritzville and the Horse Heaven Hills and by Frank Young at Ralston have consistently shown profit with these systems averaging \$25 to over \$40 per rotational acre below WW/TSF. The conventional fallow system also displayed much more income stability over years. Winter wheat/minimum tillage summer fallow (WW/MSF) has shown excellent environmental and economic prospects in low rainfall regions. Bill Schillinger and I have reported that use of a wide-blade V-sweep undercutter for primary summer fallow tillage plus fertilizer injection, followed by as few as one non-inversion rodweeding, produces statistically equivalent wheat yields and greater or equal profit. Schillinger has also documented soil moisture, surface roughness, residue, and other benefits with this system. Predicted dust emissions during severe wind events with WW/MSF were about 50% less compared to WW/TSF. An essential component of the PNW conservation efforts in both the high and lower precipitation zones has been top rate extension programs led by Kenny Morrison, Carl Engle, Roger Veseth, Don Wysocki, Hans Kok, Rich Koenig, Joe Yenish, and others. NRCS staff, including Dennis Roe and Ron McClellan, have consistently contributed key data and interpretation.

Machinery cost budgeting for direct seeding and conservation tillage by Herb Hinman, Kate Painter, and myself have shown cost savings with these systems with proper combinations of custom and owned machinery, used and new machinery, and careful matching of machinery size to direct seed and conservation-till acreage. Elwin Smith and I reported that the greatest unsung victory for soil conservation and carbon sequestration in North America has been the steady decrease in summer fallow over the past three decades. We concluded the primary reasons for the increase in cropping intensification in the American Great Plains and Canadian Prairies has been the decreasing price of glyphosate herbicide relative to diesel price and steady improvements in direct seeding technology.

David Walker and I have computed high long run productivity payoffs to soil conservation in the PNW. Our research shows that improved crop varieties, improved pest management, better nutrient management, and other technical progress has boosted yields despite soil erosion over time. However, there has been a shrinking payoff as topsoil becomes thinner. Consequently, unchecked erosion over time could eventually reduce yields despite continuing technical progress.

Despite the distinguished record of PNW conservation research and extension, and the urgency to control erosion in the long run to preserve productivity and to reduce off-site damage, the PNW lags in adoption of direct seeding and conservation tillage compared to other regions. Acreage-weighted average adoption of direct seeding in small grains for the three PNW states was 11% in 2004 versus a similar average adoption rate of 24% for the three Northern Plains states of Montana and the Dakotas (Conservation Technology Information Center (CTIC), 2004). Acreage-weighted adoption in the three Canadian prairie provinces was 32% in 2001 compared to 11% in the PNW in 2004 (Statistics Canada, 2001; CTIC, 2004).

Also vexing is the inconsistent adoption of direct seeding over PNW counties as evidenced by a recent ground survey (Hans Kok and Dennis Roe, personal communication, December 2008) and a 2004 national survey (CTIC, 2004). CTIC surveys estimate that farmers in Columbia County, WA direct seeded 68% of their acres in 2004 compared to 12% in Whitman County. Oregon's Wasco County tallied 70% in direct seeding compared to 11% in Umatilla County. In Idaho, Lewis County farmers direct seeded 33% of their acres compared to 13% in Latah County.



Doug Young inspecting windrowed canola in central Alberta.

Farmers and scientists propose diverse agronomic, agro-climatic and socio-economic hypotheses to explain low and variable rates of direct seeding and conservation tillage in the PNW. Some argue that low adoption counties confront more severe straw management, disease, weed, and topographic problems with direct seeding. Others claim custom fertilizer delivery practices inhibit direct seeding in some counties. Others posit that farmers in some high-adoption counties are more willing to burn stubble to reduce tillage at the expense of air quality. Some farmers challenge the fundamental soil conserving superiority of direct seeding and conservation tillage. They describe practices like turning moldboard plow furrows uphill, or a unique hybrid tillage system, that they claim saves soil just as well as direct seeding, but is more profitable, albeit not endorsed by NRCS or the scientific community.

A common socioeconomic explanation is that high-adoption counties have benefited from more effective educational programs. For example, Roland Schirman, an effective Extension advocate of direct seeding in Columbia County, WA, is credited for achieving 70% adoption of the practice in that county. One of Schirman's early assistants, Dusty Eddy, NRCS, is credited for similar success in Wasco County, OR. Some strong direct seed adopters might argue that farmers in high-adoption counties possess stronger stewardship values or place more value on being pioneers in conservation farming.

Although I have thought a long time about the low and variable adoption rate of direct seeding and conservation tillage in the PNW, I cannot pinpoint a single explanation. My best speculation is "all of the above, depending on the situation." Weed, disease, and straw volumes correlated with higher precipitation might be a plausible explanation for low adoption in at least some subregions within Latah, Whitman, and Umatilla counties. STEEP-funded surveys of farmers by Don Dillman, John Carlson, myself, and others lend strong support for high quality and sustained conservation education programs in promoting adoption. However, more research is needed to uncover regionally specific barriers to direct seeding.

I remain optimistic that targeted research on resolving barriers to direct seeding and conservation tillage in the PNW will eventually narrow the gap between conservation practices in our region and elsewhere. Iowa State University and Yale University economists have estimated that taxpayer investments in agricultural research at the nation's land grant universities and at USDA/ARS have yielded up to 50% rates of return since the 1970's in terms of higher grain yields. Most of these benefits are transferred to domestic and foreign consumers through lower food prices. At this point, the challenge to researchers will be to sustain higher production with resource conserving sustainable production.

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## Acknowledgement of Research Support, 2008-2009

Although the field crops research programs in Washington receive substantial funding from both state and federal appropriations, the progress we have made would not be possible without additional contributions. We are most grateful for the contributions and cooperation by the cereal and legume growers, through the commodity assessment programs, as well as contributions from the agricultural industry, which facilitates our overall agricultural research progress. In addition, a special acknowledgment goes to the numerous individual farmer cooperators who generously contribute their land, labor, equipment, and time. These cooperators and contributors include:

### COOPERATORS

Anderberg, Al—Fairfield  
 Appel, Steve—Dusty  
 Ashburn, Douglas—Genesee/Uniontown  
 Bauermeister, Dale/Dan—Connell  
 Beckley, Gregg—Benge  
 Beechinor, Jason—Walla Walla  
 Blume, Kurt—Genesee  
 Boyd, Pat—Pullman  
 Bruce, Albert/Doug—Farmington  
 Brunner, Rick—Almira  
 Burress, Randy—Moses Lake  
 CBARC—Pendleton, OR  
 Cornwall, John—Mt. Hope  
 Covington, Larry—Nespelem  
 Davis, Ryan—Pullman  
 DeLong, Sara/Joe—St. John  
 Dewald, Rob—Ritzville  
 Dietrich, Dale—Reardan  
 DM Ranch—Othello  
 Druffel, Leroy—Uniontown  
 Druffel, Mike—Colton  
 Druffel, Norm/Sons—Pullman  
 Druffel, Ross/Phil—Colton  
 Durham, Wes—Spokane  
 Els, Jim—Harrington  
 Ely, Brad—Dayton  
 Evans, Jim—Genesee  
 Felgenhauer, Karl—Fairfield  
 Fleming, Chad—Lacrosse  
 Fleming, Darrin—Lacrosse  
 Gady, Larry/David—Rockford  
 Harlow, David—Pullman  
 Haugerud, Nick—Colfax  
 Hauser, Gary—Pomeroy  
 Heimbigner, Ross—Ritzville  
 Hennings, Curtis/Erika—Ralston  
 Hennings, Ron—Ritzville  
 Herdrick, Tim—Wilbur  
 Herron, Chris—Connell  
 Hirst, Jim—Harrington  
 Idaho, Univ. Kambitsch Farms—Genesee, ID  
 Jacobsen, Adelbert/Neil—Waterville  
 Jirava, Ron—Ritzville  
 Johnson, Frank/Jeff—Asotin  
 Johnson, Hal—Davenport  
 Jones, Rick—Wilbur  
 Jorgensen, Keith/Owen—St. Andrews  
 Juris, Ron—Bickleton  
 Knodel, Jerry—Ralston  
 Koller, Randy/Roger—Pomeroy  
 Kramer, Mark—Harrington  
 Krause, Jerry—Creston  
 LaFave, John—Moses Lake

Laney, Chris—Sprague  
 Lange, Frank—Palouse  
 Leahy, Ed—Walla Walla  
 Lyons, Rusty—Waitsburg  
 Mader, Dan—Genesee  
 Mader, Steve—Pullman  
 Madison, Kent—Hermiston, OR  
 Maier, Eric—Ritzville  
 Marks, Scott—Connell  
 Matsen, Steve—Bickleton  
 McKay, Dan—Almira  
 McKinleyk, Dan—Waitsburg  
 McLean, John/Shirley—Coulee City  
 Mills, Mac/Rod—St. John  
 Monson, Jason—Lacrosse  
 Moomaw, Cherie—Omak  
 Morasch, Bob—Endicott  
 Nelson, Bruce—Farmington  
 Nelson, Howard—Wilbur  
 Nichols, Mike—Horse Heaven Hills  
 Ostheller, David—Fairfield  
 Pearson, Dave—Horse Heaven Hills  
 Pennell, Roger—Garfield  
 Penner, Jay—Dayton  
 Pfaff, Richard—Farmington  
 Pottratz, Dennis—Fairfield  
 Rausch, Chris—Lexington, OR  
 Richter, Mark—Endicott  
 Roseberry, Dave—Prosser  
 Sauer, Bruce—Lind  
 Sawyer, John—Palouse  
 Schafer, Derek—Ritzville  
 Schibel, Jeff—Odessa  
 Schmitt, Mike/Dan—Horse Heaven Hills  
 Schmitz, Joe—Rosalia  
 Schoesler, Mark—Ritzville  
 Schultheis, Art—Colton  
 Sheffels, Mark—Wilbur  
 Smith, Glen—Waitsburg  
 Smith, Steve—Horse Heaven Hills  
 Snyder, Jerry—Ralston  
 Spangler, Dennis—Connell  
 Stubbs, Jerry/Mike—Dusty  
 Sues, Randy—Colfax  
 Swannack, Steve—Lamont  
 Tanneberg, Jason—Mansfield  
 Tanneberg, Larry—Coulee City  
 Thorn, Eric—Dayton  
 Tiegs, Brian—Fairfield  
 Townsend, Ed—Omak  
 Walters, Craig—Palouse  
 Wesselman, Roger—Mansfield  
 White, Gil—Lamont  
 Zenner, Russ—Genesee

**CONTRIBUTORS**

Agri-Pro  
Agrium  
Amen Endowment, Otto & Doris  
American Malting Barley Assn.  
Andersen Machine Inc.  
Arizona Plant Breeders  
BASF  
Bayer Corp.  
BNP Lentil  
Busch-Ag Resources  
BNP Lentil  
Busch-Ag Resources  
CalWest Seed  
Cedbeco Zaden BV  
Central Washington Grain Growers  
CLD Pacific Grain  
Co-Ag, Inc.  
Columbia Co. Grain Growers  
Columbia Grain Int'l.  
Connell Grain Growers  
Crites  
DOW Agrosience  
DuPont  
Empire, Inc.  
Evans Enterprises  
Fluid Fertilizer Foundation  
FMC Corp.  
Foundation for Agronomic Research  
Genesee Union Warehouse  
General Mills  
GMG  
Grant Co. Crop Improvement Assn.  
Great Plains Mfg.  
Great Western Malting  
Gustafson, Inc.  
Harvest States  
Horsch Maschinen GmbH  
Idaho Barley Commission  
International Plant Nutrition Institute  
Johnson Union Warehouse  
Land Institute  
Laughlin Trading Co.  
Lincoln/Adams Crop Improvement Assn.  
McCubbins, Mike  
McGregor Co.  
McKay Seeds  
Merrill Lewis  
Micro-Ag, Inc.  
Microsoft Corp.  
Monsanto Co.  
Moore, Jim & Ann  
North Pine Ag Supply  
Northwest Grain Growers  
Nu Chem  
Odessa Union Warehouse Co-op  
Pioneer Seeds  
Pomeroy Farm & Home Supply  
Primeland  
ProGene  
Quincy Farm Chemicals, Inc.  
Reardan Seed Co.  
Resource Seeds  
Ritzville Grain Growers  
Seedex  
SeedTec  
Simplot  
Small Planet Foods  
Spectrum Crop Development  
Spokane Co. Assn. Wheat Growers  
Spokane Co. Crop Improvement Assn.  
Spokane Seed  
St. John Grain Growers  
Syngenta  
Tomco Seed  
Trigen Seeds, Inc.  
USDPLC  
Valent USA Corp.  
Von Wettstein, Diter  
W.F. Wilhelm & Son, Inc.  
WA State Dept. of Ecology  
Wagner Seeds  
Walter Implement Co.  
Washington Assn. Wheat Growers  
Washington Barley Commission  
Washington Wheat Commission  
Westbred, LLC  
Western Ag Innovations  
Western Farm Service  
Whitman Co. Growers  
Wilbur-Ellis Co.  
WSU Center for Sustaining Agriculture and Natural Resources  
WSCIA



## Cook Agronomy Farm

In 1998, a team of Washington State University and USDA-ARS scientists launched a long-term direct-seed cropping systems research program on 140 acres of the WSU-owned Cook (formerly referred to as 'Cunningham') Agronomy Farm located 7 miles NE of Pullman, WA. The goals are to:

- Play a leadership role through research, education and demonstration in helping growers in the high-precipitation areas of the Inland Northwest make the transition agronomically and economically to continuous direct-seeding (no-till farming) of land that has been tilled since farming began near the end of the 19th century.
- Provide databases and understanding of the variable soil characteristics, pest pressures, and historic crop yield and quality attributes over a typical Palouse landscape as the foundation for the adoption and perfection of precision-agriculture technology in this region.

These two goals are intended to facilitate the greatest technological changes for Northwest agriculture since the introduction of mechanization early in the 20th century. Growers and agribusinesses are recognizing both the need for and opportunities presented by these changes.

The past 9 years have been used to obtain site-specific data and develop physical maps of the 140-acre farm, with the greatest detail developed for a 92-acre watershed using 369 GPS-referenced sites on a nonaligned grid. Maps are available or being developed from various sampling efforts that characterize crop yield and economic returns, soil types, weed seed banks, populations of soilborne pathogens, soil pH, carbon sequestration, soil water and nitrogen supplies, nitrogen use efficiency and precision N applications. This has been achieved while producing a crop of hard red spring wheat in 1999, spring barley in 2000, and initiating six direct-seed cropping system rotations starting in the fall of 2001 that have continued through today. This past year, an adjacent 160 ac were added to the overall Cook Agronomy Farm bringing the total land area to 300 ac. This new acreage will provide much needed land for small plot research that can complement larger scale cropping system efforts.

The 92-acre portion of this farm is unquestionably the most intensively sampled and mapped field in the Inland Northwest. Some 20-25 scientists and engineers are now involved in various aspects of the work started or planned for this site. A 12-member advisory committee consisting of growers and representatives of agribusiness and government regulatory agencies provide advice on the long-term projects and the day-to-day farming operations, both of which must be cutting edge to compete scientifically and be accepted practically. This farm can become a showcase of new developments and new technologies while leading the way towards more profitable and environmentally friendly cropping systems based on direct seeding and precision farming.

## Dryland Research Station

The Washington State University Dryland Research Station was created in 1915 to "promote the betterment of dryland farming" in the 8-to 12-inch rainfall area of eastern Washington. Adams County deeded 320 acres to WSU for this purpose. The Lind station receives an average of 9.6 inches of annual precipitation, the lowest of all state or federal dryland agricultural research facilities in the United States.



Research efforts at Lind throughout the years have largely centered on wheat. Wheat breeding, variety adaptation, weed and disease control, soil fertility, erosion control, and residue management are the main research priorities. Wanser and McCall were the first of several varieties of wheat developed at the Lind Dryland Research Station by plant breeding. Twenty acres of land can be irrigated for research trials. Numerous journal articles have been published throughout the years from research conducted at the

Lind Station and in farmers' fields throughout the low-rainfall region. The articles are available online at <http://www.lindstation.wsu.edu>.

The facilities at Lind include a small elevator which was constructed in 1937 for grain storage. An office and attached greenhouse were built in 1949 after the old office quarters burned down. In 1960, a 40' x 80' metal shop was constructed with WSU general building funds. An addition to the greenhouse was built with Washington Wheat Commission funding in 1964. In 1966, a deep well was drilled, testing over 430 gallons per minute, and an irrigation system installed. A modern laboratory and storage building was built in 1983 and later dedicated to Richard Deffenbaugh, former chair of the Washington Wheat Commission and longtime promoter of the Dryland Research Station. A machine storage building was completed in 1985.

Growers raised funds in 1996 to establish an endowment to support the WSU Dryland Research Station. The endowment is managed by a committee of growers and WSU faculty. Grower representatives from Adams, Franklin, Benton, Douglas, Lincoln, and Grant counties are appointed by their respective county wheat growers associations. Endowment funds support facility improvement, research projects, equipment purchase, and other identified needs. State Senator Mark Schoesler led a successful effort in 1997 to transfer ownership of 1000 acres of adjoining state-owned farmland to the WSU Dryland Research Station.

Since 1916, an annual field day has been held to show growers and other interested people the research on the Station. Visitors are welcome at any time, and your suggestions are appreciated.

## Palouse Conservation Field Station

The Palouse Conservation Field Station (PCFS) originated in 1930 as one of 10 original erosion experiment stations established across the United States by Congressional funding to USDA. The research programs of the stations were designed to investigate the causes of erosion and to determine the most effective and practical methods of checking and controlling soil and water losses from agricultural lands. In 1935 the Soil Conservation Service (SCS) was established and the PCFS became a part of SCS research. When the Agricultural Research Service (ARS) was established in 1953, all SCS research, including the PCFS, was transferred to ARS. The Land Management and Water Conservation Research Unit (LMWCRU) that oversees the PCFS was officially formed in 1972 as an outcome of a major reorganization of ARS.



Historically, the LMWCRU has played a leading role in the development of science-based solutions to agricultural and environmental problems of the Pacific Northwest. Research on conservation tillage, soil quality, integrated pest management and soil erosion prediction and control have promoted the economic and environmental vitality of the region's agriculture by providing state-of-the-art technologies and management strategies. The research program of the scientists and staff has evolved over time as problems and issues change. Scientists and engineers from the ARS and Washington State University currently utilize the PCFS to conduct research projects ranging from soil erosion by wind and water to field-scale cropping and tillage practices on the steep slopes common on the Palouse. Both federal and state researchers, graduate students, and technicians conduct part or all of their research at the PCFS.

An ARS farm manager is assigned to the PCFS and is responsible for maintaining the station infrastructure, coordinating the complex planting and harvest schedule to meet the requirements of the various cropping systems research plots, and operating the machine shop, which fabricates much of the equipment used in the research projects. The PCFS infrastructure currently consists of several buildings including offices, soils laboratory, plant-drying facility, rain tower with tilting flume, greenhouse, machine shop, and equipment buildings, as well as the 202-acre research farm.

Today, the LMWCRU's research is actively engaged in issues of national as well as regional prominence. In collaboration with producers, land-grant universities, national laboratories, agribusiness, grower associations and commodity groups, state and federal agencies and other USDA-ARS Units across the nation, at PCFS and other locations, LMWCRU scientists conduct research on: 1) Integrated agricultural systems including cereal-based rotations, direct seed systems, biofuels, alternative crops, weed management strategies, and organic farming systems; 2) Management systems and decision models to prevent wind blown dust and improve air quality and prevent water erosion; 3) Carbon sequestration, sustainable soil management, and mitigation of global climate change; and 4) Precision agricultural systems for effective and sustainable use of fertilizer and herbicides.

## Spillman Agronomy Farm

The Spillman Agronomy Farm is located on 382 acres five miles southeast of Pullman, WA in the midst of the rich Palouse soils. In the fall of 1955, an initial 222 acres of land were acquired from Mr. and Mrs. Bill Mennet at the arbitrated price of \$420 per acre. The money for the original purchase came as the result of a fund drive which raised \$85,000 from industry and wheat growers. In addition, \$35,000 came from the Washington State University building fund, \$11,000 from the State Department of Agriculture, and another \$10,000 from the 1955-57 operating budget. A headquarters building, which is 140 feet long and 40 feet wide, was completed in 1956 followed in 1957 by a well that produced 340 gallons per minute. The dedication of the farm and new facilities took place at the Cereal Field Day July 10, 1957.

In 1961, the Agronomy Farm was named Spillman Farm after Dr. William Jasper Spillman (1863-1931), the distinguished geneticist and plant breeder at Washington State University that independently rediscovered Mendel's Law of Recombination in 1901.



William J. Spillman, breeding plots at Pullman, 1900

Through the initiative of Dr. Orville Vogel, USDA Wheat Breeder at WSU, and the dedicated efforts of many local people, arrangements were made to acquire an additional 160 acres north of the headquarters building in the fall of 1961. This purchase was financed jointly by the Washington Wheat Commission and Washington State University. The newly acquired 160 acres was contiguous with the original 222 acres and became an integral part of the Spillman Agronomy Farm.

Facility updates to Spillman Agronomy Farm include: (1) a 100- by 40 foot machine storage addition built in 1981, (2) in 1968, the Washington Wheat Commission provided funds for a sheaf storage facility and at the same time (3) the Washington Dry Pea and Lentil Commission provided \$25,000 to build a similar facility for the pea and lentil materials. The facilities of the Spillman Agronomy Farm now range in value well over a half million dollars.

Development of Spillman Agronomy Farm was always focused with proper land use in mind. A conservation farm plan which includes roads, terraces, steep slope plantings, and roadside seedings has been in use since the farm was purchased. In addition, current breeders are utilizing the acreage to develop cropping systems that will include opportunities to include organic, perennial and biotechnological components in cereal and legume breeding programs.

On July 7, 2005, over 330 people attended a special 50th Anniversary Field Day at Spillman Agronomy Farm that included three faculty/staff that were present at the July 10, 1957 dedication: Dr. Robert Nilan (WSU Barley Breeder), Dr. Cal Konzak (WSU Wheat Breeder), Dr. Robert Allan (USDA/ARS Wheat Geneticist) and Carl Muir (Tech Supervisor, WSU Barley Breeding Program). Dr. Allan also presented the keynote luncheon address at the 50th Anniversary Field Day and reaffirmed the significance of Spillman Agronomy Farm in his opening remarks: "The importance of Spillman Farm will not diminish as time passes. Multimillion dollar structures on campus will not replace its (Spillman Agronomy Farm) vital role in crop development."



The Spillman Agronomy Farm continues to exemplify the vision of public and private cooperation that has become the 'home' for cereal and pulse crop research and development at Washington State University for over 50 years.

## **Wilke Research and Extension Farm**

The Wilke Research and Extension Farm is located on the east edge of Davenport, WA. The 320-acre farm was bequeathed to WSU in the 1980's by Beulah Wilson Wilke for use as an agricultural research facility. A local family has operated the farm for approximately 60 years. Funding for the work at the Wilke Farm comes from research and extension grants and through the proceeds of the crops grown. Goals for research at the Wilke Farm are centered around the need to develop cropping systems that enhance farm profitability and soil quality.

The Wilke Farm is located in the intermediate rainfall zone (12-17 inches of annual precipitation) of eastern Washington in what has historically been a conventional tillage, 3-year rotation of winter wheat, spring cereal (wheat or barley), followed by summer fallow. Wheat is the most profitable crop in the rotation and the wheat-summer fallow rotation has been the most profitable system for a number of years.

The farm is split in half by State Highway 2. The north side has been in continuous winter or spring cereal production for approximately 14 years and being cropped without tillage for the past 9 years. Since 1998, the south side has been dedicated to the Wilke Research Project that is testing a direct seed, intensive cropping system. The south side of the Wilke Farm was divided into 21 separate plots that are 8 to 10 acres in size and farmed using full-scale equipment. In 2003 these plots were combined into 7 separate plots approximately 27 acres in size. Three plots remain in a 3-year crop rotation that includes winter wheat, chemical fallow, and spring crop. Four plots remain in a 4-year crop rotation that includes winter wheat, chemical fallow, spring cereal and spring crop. Crops grown on the farm since the inception of the Wilke Project in 1998 include barley, winter and spring wheat; canola, peas, safflower, sunflowers, yellow mustard, and proso millet. The farm provides research, demonstration, education and extension activities to further the adoption of direct-seeding systems in the area. The Wilke Farm is a collaborative approach to develop direct seed systems that include local growers, WSU research and extension faculty, NRCS, agribusiness, Lincoln County Conservation District, and EPA. In addition, the Wilke Farm is used increasingly for small plot research by WSU faculty and private company researchers for small plot cropping systems research.

Due to its location and climate, the Wilke Farm complements other WSU dryland research stations in the Palouse area and at Lind and other locations in the region such as north central Oregon.

## Variety History at WSU

### Wheat Varieties

COMPILED BY STEVE LYON

**VARIETY..... YEAR RELEASED..... MARKET CLASS ... BACKGROUND / NAMED AFTER**

#### SPILLMAN

Hybrid 60	1905	HWW Club	Lost
Hybrid 63	1907	SWS Club	Turkey/ Little Club; still grown at Spillman Farm
Hybrid 108	1907	SRS Club	Jones Fife/Little Club; lost
Hybrid 123	1907	SWS Club	Jones Fife/Little Club; still grown at Spillman Farm
Hybrid 128	1907	SWW Club	Jones Winter Fife/Little Club; still grown at Spillman Farm
Hybrid 143	1907	SWS Club	White Track/Little Club; still grown at Spillman Farm

#### GAINES

Mayview	1915	SRS	Selected from field of Fortyfold near Mayview
Triplet	1918	SRW	Jones Fife/Little Club//Jones Fife/Turkey
Ridit	1923	HRW	Turkey/Florence; first cultivar in USA released with smut resistance
Albit	1926	SWW Club	Hybrid 128/White Odessa
Flomar	1933	HWS	Florence/Marquis
Hymar	1935	SWW Club	Hybrid 128/Martin

#### VOGEL

Orfed	1943	SWS	Oro/Federation
Marfed	1946	SWS	Martin/Federation
Brevor	1947	SWW	Brevon/ Oro
Orin	1949	SWW	Orfed/Elgin
Omar	1955	SWW Club	Oro and Elmar in pedigree
Burt	1956	HWW	Burton Bayles, principal field crop agronomist for ARS
Gaines	1961	SWW	EF Gaines (Vogel's professor) WSU Cerealist, 1913-1944
Nugaines	1965	SWW	Sister line of Gaines (new Gaines)

#### NELSON

McCall	1965	HRW	M.A. McCall, first superintendent of Lind Station
Wanser	1965	HRW	HM Wanser, early dryland agronomist

#### ALLAN

Paha	1970	SWW Club	Rail point (town) in Adams Co. between Lind and Ritzville
Coulee	1971	HWW	Town in Grant Co.
Tyee	1979	SWW Club	Rail point (town) in Clallam Co. between Beavor and Forks
Crew	1982	SWW Club	Multiline with 10 components (crew of 10)
Tres	1984	SWW Club	Spanish for three. Resistant to stripe rust, leaf rust & powdery mildew
Madsen	1988	SWW Club	Louis Madsen, Dean of College of Agriculture at WSU, 1965-1973
Hyak	1988	SWW Club	Rail point in Kittitas Co. east of Snoqualmie pass
Rely	1991	SWW Club	Multiline with reliable resistance to stripe rust
Rulo	1994	SWW Club	Rail point in Walla Walla Co.
Coda	2000	SWW Club	The finale (of a symphony). R.E. Allan's last cultivar

#### BRUEHL

Sprague	1972	SWW	Rod Sprague, WSU plant pathologist. First snowmold resistant variety for WA
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#### PETERSON

Luke	1970	SWW	Name of Nez Perce Indian that saved Rev. H.H. Spalding's life near Lapwai, ID
Norco	1974	SWW	Released as cultivar then recalled in 1975 due to susceptibility to new stripe rust race
Barbee	1976	Club	Earl Barbee, WSU agronomist
Raeder	1976	SWW	Plant pathologist JM Raeder, U. of ID professor of CJ Peterson
Daws	1976	SWW	Dawson Moodie, chair, Dept. of Agronomy, WSU
Lewjain	1982	SWW	Lew Jain, farmer friend of Peterson
Dusty	1985	SWW	Town in Whitman Co.

Eltan .....	1990 .....	SWW .....	Elmo Tanneberg, Coulee City, WA wheat farmer/supporter
Kmor.....	1990 .....	SWW .....	Ken Morrison, WSU Ext. State Agronomist
Rod .....	1992 .....	SWW .....	Rod Betramson, chair, Dept of Agronomy, WSU
Hiller.....	1998 .....	SWW Club .....	Farmer/cooperator in Garfield Co.

**KONZAK**

Wandell .....	1971 .....	Spring Durum .....	WA + ND (North Dakota) + ELL (?)
Wared .....	1974 .....	HRS .....	WA + red (HRS)
Urquie .....	1975 .....	SWS .....	Urqhart, a farmer near Lind, WA
Walladay.....	1979 .....	SWS .....	WA + Dayton (town in WA)
Wampum.....	1980 .....	HRS .....	WA + wampum (Native American term for money, medium of exchange)
Waid .....	1980 .....	Spring Durum .....	WA + ID, first WSU variety developed via induced mutation, also licensed in Europe
Waverly .....	1981 .....	SWS .....	Town in WA
Edwall.....	1984 .....	SWS .....	Town in WA
Penewawa.....	1985 .....	SWS .....	Old town area in WA
Spillman .....	1987 .....	HRS .....	WJ Spillman, first WSU wheat breeder
Wadual .....	1987 .....	SWS .....	WA + dual; dual quality, pastry and bread, new concept for SW wheat
Wakanz.....	1987 .....	SWS .....	WA + kan (KS -hessian fly testing) + nz (New Zealand - winter increase)
Calorwa .....	1994 .....	SWS Club .....	CA(California) + OR (Oregon) + WA
Alpowa .....	1994 .....	SWS .....	Town in WA
Wawawai .....	1994 .....	SWS .....	Area or old town in WA

**DONALDSON**

Hatton .....	1979 .....	HRW .....	Town in Adams Co.
Batum .....	1985 .....	HRW .....	Rail point in Grant Co.
Andrews.....	1987 .....	HRW .....	Old town in Douglas Co.
Buchanan .....	1990 .....	HRW .....	Historical family name near Lind
Finley.....	2000 .....	HRW .....	Town in Benton Co.

**KIDWELL**

Scarlet .....	1999 .....	HRS .....	Red seed color
Zak .....	2000 .....	SWS .....	Cal Konzak, WSU spring wheat breeder
Macon .....	2002 .....	HWS .....	Vic Demacon, WSU spring wheat researcher
Tara 2002.....	2002 .....	HRS .....	"Gone with the Wind" theme
Eden .....	2003 .....	SWS Club .....	"Gone with the Wind" theme
Hollis .....	2003 .....	HRS .....	Grandfather of Gary Shelton, WSU spring wheat researcher
Louise .....	2004 .....	SWS .....	Nickname of the Breeder's neice
Otis .....	2004 .....	HWS .....	Nickname of the Breeder's nephew
Farnum .....	2008 .....	HRW .....	Major road in Horse Heaven Hills
Whit .....	2008 .....	SWS .....	Suitable to Whitman County
Kelse .....	2008 .....	HRS .....	Niece of Kidwell
JD.....	2009 .....	SWS Club .....	In honor of Jim Moore and family (Kahlotus wheat producer)
Babe.....	2009 .....	SWS .....	In honor of Dr. Kidwell's parents

**JONES**

Edwin .....	1999 .....	SWW Club .....	Edwin Donaldson, WSU Wheat Breeder
Bruehl.....	2001 .....	SWW Club .....	George (Bill) Bruehl, WSU Plant Pathologist
Masami .....	2004 .....	SWW Club .....	Masami (Dick) Nagamitsu, WSU wheat researcher
Bauermeister.....	2005 .....	HRW .....	Dale and Dan Bauermeister, Connell, WA wheat farmers/cooperators
MDM .....	2005 .....	HWW .....	Michael Dale Moore, Kahlotus area farmer/cooperator
Xerpha.....	2008 .....	SWW .....	WSU botanist and wife of Edward Gaines

**CAMPBELL**

Finch .....	2002 .....	SWW .....	WA bird
Chukar.....	2002 .....	SWW Club .....	WA bird and names clubs beginning with a 'C'
Cara .....	2007 .....	SWW Club .....	Short and starts with a 'C'



## Barley Varieties

COMPILED BY STEVE ULLRICH

Name	Year	Market Class	Breeder	Comments
Olympia .....	1937	winter, 6-row, feed .....	Gaines.....	introduction from Germany collected in 1935
Rufflynn .....	1939	spring, 6-row, feed .....	Barbee .....	selection from Flynn ( Club Mariout / Lion)
Belford.....	1943	spring, 6-row, hay .....	Barbee .....	selection from Beldi Giant / Horsford
Velvon 17 .....	1947	spring, 6-row, feed .....	Gaines.....	selection from Velvon Composite 1 ( Colorado 3063 / Trebi )
Heines Hanna ...	1957	spring, 2-row, malting .....	Gaines.....	introduction from Germany collected in 1925 (selected From a Czech landrace)
Luther.....	1966	winter, 6-row, feed .....	Nilan.....	induce mutant of Alpine (first induced mutant variety released in North America)
Vanguard.....	1971	spring, 2-row, malting .....	Nilan.....	selection from Betzes / Haisa II // Piroline
Kamiak .....	1971	winter, 6-row, feed .....	Nilan.....	selection from Bore / Hudson
Steptoe.....	1973	spring, 6-row, feed .....	Nilan.....	selection from WA 3564 (sel. From CC V) / Uniton
Blazer.....	1974	spring, 6-row, malting .....	Nilan.....	selection from Traill / WA1038 (induced mutant)
Boyer .....	1975	winter, 6-row, feed .....	Muir.....	selection from Luther / WA1255-60
Advance.....	1979	spring, 6-row, malting .....	Nilan.....	Foma/Triple Bearded Mariout// White Winter (WA6194-63)/3/Blazer
Andre.....	1983	spring, 2-row, malting .....	Nilan.....	selection from Klages / Zephyr
Showin .....	1985	winter, 6-row, feed .....	Ullrich .....	selection from 68-1448 / 2116-67
Cougar.....	1985	spring, 6-row, feed .....	Ullrich .....	selection from Beacon // 7136-62 / 6773-71
Hundred.....	1989	winter, 6-row, feed .....	Ullrich .....	selection from WA2196-68 / WA2509-65
Crest .....	1992	spring, 2-row, malting .....	Ullrich .....	selection from Klages /2* WA8537-68
Bear.....	1997	spring, 2-row, hulless.....	Ullrich .....	selection from Scout / WA8893-78
Washford.....	1997	spring, 6-row, hay .....	Ullrich .....	selection from Columbia / Belford
Farmington .....	2001	spring, 2-row, feed .....	Ullrich .....	WA10698-76 // Piroline SD Mutant / Valticky SD Mutant /3/ Maresi
Bob .....	2002	spring, 2-row, feed .....	Ullrich .....	selection from A308 ( Lewis somaclonal line ) / Baronesse
Radiant .....	2003	spring, 2-row, feed .....	Wettstein .....	selection from Baronesse / Harrington proant mutant 29-667

## Dry Pea, Lentil and Chickpea Varieties

COMPILED BY FRED MUEHLBAUER AND KEVIN MCPHEE

The grain legume industry started in the early 1900s and progressed from using relatively old landraces to more advanced varieties produced by breeding programs. Initially, dry peas were produced from varieties that were commonly used for canning of fresh peas. Such varieties as 'Small Sieve Alaska', 'Alaska', 'First and Best' were commonly grown. These varieties gave way to 'Columbian', which is still the industry standard for color quality, and the so-called "stand-up varieties" such as 'Stirling'. Numerous varieties of the so-called stand-up peas have been developed and are in use for dry pea production. Lentil production began in the early 1920s on a small scale in the Farmington area and increased rapidly in the 1950s and 1960s. Varieties grown initially were described as "Persians" and "Chilean" types. The variety 'Brewer' released in 1984 quickly became the industry standard for the Chilean type. Other varieties such as 'Pardina', 'Redchief', 'Crimson', 'Pennell' and 'Merri' are currently important lentil varieties. Chickpea production began in the Palouse in the early 1980s and quickly expanded to become an important crop for the region. However, the devastating effects of *Ascochyta* blight reduced production in the area to a minimum until resistant varieties such as 'Sanford' and 'Dwelley' were developed and released in 1994 and more recently 'Sierra' in 2003 and 'Dylan' in 2006. Spanish White types are a premium product and 'Troy' is the first *Ascochyta* blight resistant variety of this class to be developed.

The historical grain legume varieties show apparent changes made through breeding from the earlier types that were grown to the present day varieties. Varieties in the historical nursery include all three crops and are described as follows:

**DRY PEAS**Spring Green Peas

Small Sieve Alaska – An old variety initially used for canning small green peas. It was used on a limited basis to produce dry peas with small seed size for specialty markets.

Garfield – Released in 1977 by USDA-ARS. The variety has long vines and larger seeds than other Alaska types.

Tracer – Released in 1977 by USDA-ARS. The variety was intended as a replacement for Small Sieve Alaska. It has a triple podding habit.

Columbian – Developed by the Campbell Soup Company for making split pea soup with good color. A green dry pea used by the industry because of excellent color qualities and good yields.

Alaska-81 – Released in 1984 by USDA-ARS, seeds are dark green, round and smooth with green cotyledons. Immune to pea seed borne mosaic virus and resistant to Fusarium wilt race 1.

Joel – A medium sized, green cotyledon dry pea released in 1997 by USDA-ARS. The variety has improved green pea color quality and has resistance to powdery mildew and Fusarium wilt race 1.

Lifter – A green cotyledon dry pea released in 2001 by USDA-ARS. The variety has multiple disease resistance, persistent green color of the seeds and yields are improved over Columbian and Joel. It has a dwarf plant habit with normal leaves.

Franklin – A green cotyledon dry pea released in 2001 by USDA-ARS. The variety is resistant to Fusarium wilt race 1, pea enation mosaic virus, and powdery mildew.

Stirling – A green cotyledon dry pea released in 2004 by USDA-ARS. It is a semi leafless stand up variety with resistance to Fusarium wilt race 1 and powdery mildew.

Medora – A green cotyledon dry pea released in 2006 by USDA-ARS. The variety was released for improved plant height and lodging resistance. It also has resistance to powdery mildew.

Spring Yellow Peas

First and Best – Was one of the first yellow pea varieties grown in the Palouse region.

Latah – Released in 1977 by USDA-ARS. The variety was a pure line selection from First and Best.

Umatilla - Released in 1986 by USDA-ARS, 'Umatilla' is about 15 cm shorter and is higher yielding when compared to Latah. Resistant to Fusarium wilt race 1 and tolerant to pea root rot.

Shawnee - A large seeded, yellow cotyledon dry pea released in 1997 by USDA-ARS. 'Shawnee' has large seed size, bright yellow seed color and resistance to powdery mildew.

Fallon - A large seeded, yellow cotyledon dry pea released in 1997. The variety is resistant to powdery mildew and with a semi-leafless upright growth habit.

Winter Peas

Common Austrian Winter Pea – The original Austrian Winter pea was grown extensively in the Palouse region for green manure plow down since the early 1900s. Improved types such as Melrose and more recently Granger have replaced the variety.

Melrose – An improved Austrian Winter pea released by the University of Idaho in 1978.

Granger - A semi leafless Austrian winter-type pea released in 1996 by USDA-ARS.

Specter – A white flowered winter pea released by USDA-ARS in 2004 as a feed pea. The variety is semi leafless and has yellow cotyledons. It is resistant to Fusarium wilt race 1 and 2.

Windham – A white flowered winter pea released by USDA-ARS in 2006 as a feed pea. The variety is semi leafless, has a dwarf plant habit, lodging resistance and has yellow cotyledons. It is resistant to Fusarium wilt race 1.

**LENTILS**Brewer Types

Chilean – A large seeded yellow cotyledon variety introduced into the region in 1920.

Brewer – A large seeded yellow cotyledon lentil with larger and more uniform seeds, released in 1984 by USDA-ARS.

Merrit – A large seeded yellow cotyledon variety released by USDA-ARS in 2003. The variety has seed coat mottling and is expected to replace Brewer.

Laird Types

Tekoa – A large seeded yellow cotyledon variety released by USDA-ARS in 1969. The variety had an absence of seed coat mottling.

Palouse – Released by USDA-ARS in 1981. The variety has large seed size and an absence of seed coat mottling.

Pennell – A large seeded yellow cotyledon variety released by USDA-ARS in 2003. The variety lacks seed coat mottling.

Mason – A large seeded, yellow cotyledon lentil released in 1997 by USDA-ARS. Mason has large seed size and no seed coat mottling.

Riveland – A large seeded yellow cotyledon lentil released in 2006 by USDA-ARS. Riveland has extremely large seed and lacks seed coat mottling.

#### Small-seeded Types

Pardina – A small, yellow cotyledon type cultivar with brown and speckled seed coats. It was introduced by the lentil industry from Spain and is now being produced extensively in the Palouse.

Richlea – Developed and released in Canada. The variety has medium sized seeds with yellow cotyledons and an absence of seed coat mottling. It is high yielding.

Eston – Developed and released in Canada. The variety has small seed size with yellow cotyledons.

Emerald – Released in 1986 by USDA-ARS, is a green seeded lentil cultivar with distinctive green cotyledons.

#### Turkish Red Types

Redchief – Released in 1980 by USDA-ARS, is a large-seeded red-cotyledon-type cultivar with seed coats that lack mottling.

Crimson – A small seeded, red cotyledon type lentil cultivar, released in 1990 by USDA-ARS. It originated as a pure line selection from 'Giza-9', a cultivar developed in Egypt and introduced into the U.S. by the ARS Grain Legume Program.

Morton – Morton is a small seeded red cotyledon winter hardy lentil that was developed specifically for use in direct seed or minimum-tillage cropping systems. The variety was released in 2002.

### **CHICKPEAS**

#### Kabuli Type

Burpee 5024 – A large seeded Kabuli variety distributed by the Burpee Seed Company. We use the variety extensively in our Ascochyta blight screening nursery as a susceptible check.

Surutato 77 – A large seeded Kabuli variety developed and released in Mexico. The variety has very large seeds and was one of the first varieties of chickpea grown in the Palouse region. The variety is very susceptible to Ascochyta blight.

Tammany – Released by USDA-ARS in 1986. The variety is a large seeded Kabuli variety that is similar to Macarena from Mexico. The variety is very susceptible to Ascochyta blight.

UC-5 – A large seeded Kabuli variety developed and released in California. It was introduced into the Palouse in the late 1980s. The variety is very susceptible to Ascochyta blight.

UC-27 – A medium sized Kabuli variety developed and released in California. It was introduced into the Palouse in the late 1980s. The variety is very susceptible to Ascochyta blight.

Spanish White – Introduced from Spain into the Palouse in the mid 1980s as a large seeded Kabuli variety with white seeds. It is a specialty type in Spain. The variety is very susceptible to Ascochyta blight.

Blanco Lechoso – Similar to Spanish White. The variety has exceptionally large and white seeds. However, it is very susceptible to Ascochyta blight.

Sarah – Released by USDA-ARS in 1990. Sarah is a desi type and is susceptible to Ascochyta blight.

Dwelley – A large seeded Café type chickpea released in 1994 by USDA-ARS. Dwelley has good resistance to Ascochyta blight and is a sister line to Sanford.

Sanford – A large seeded Café type chickpea released in 1994. Sanford has a good resistance to Ascochyta blight and is a sister line to Dwelley.

Evans – A large seeded Café type chickpea released in 1997. Evans is earlier flowering and earlier to mature when compared with Sanford and Dwelley.

Sierra – A large seeded Café type chickpea released in 2003 by USDA-ARS. Sierra has improved resistance to Ascochyta blight when compared to Sanford and Dwelley.

Dylan – A large seeded Café type chickpea released in 2006 by USDA-ARS. Dylan has improved resistance to Ascochyta blight when compared to Sanford and Dwelley and a lighter seed coat color.

Troy – A large seeded Spanish White type chickpea released in 2007 by USDA-ARS. Troy has improved resistance to Ascochyta blight when compared to Sanford and Dwelley and is a replacement for the earlier Ascochyta blight susceptible Spanish White type varieties. Its extremely large seed size and bright white seed coat color are desirable quality traits and distinguish this variety from other releases.

Sawyer – A medium-seeded Café type chickpea released in 2008. Sawyer has improved resistance to Ascochyta blight compared to Sierra, Dylan and Troy. It has high yield potential across a wide geographical area from eastern Washington to North Dakota.

#### Desi Type

Myles – A desi type chickpea released in 1994. Myles has very good resistance to Ascochyta blight.



## Part 1. Breeding, Genetic Improvement, and Variety Evaluation

### Winter Wheat Breeding, Genetics, and Cytology

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**Xerpha** was the highest yielding soft white winter (SWW) entry in the WSU Extension Uniform Variety Testing (VT) Program's Soft White winter wheat trials for 2008. This is the third consecutive year that Xerpha has topped the mean grain yield for Washington, out-yielding 49 other varieties, breeding lines and blends from 10 different breeding programs averaged across 19 locations. It is interesting to note that in 2006 Xerpha was the top yielding breeding line in all of our advanced breeding nurseries. Today, just three years later, Xerpha seldom tops any of our breeding nurseries. We now have numerous lines with diverse pedigrees that consistently out-yield Xerpha and we are advancing these lines as rapidly as possible towards full release status.

**Masami**, in just its second year of commercial production, continues to rank as one of the top 10 varieties statewide and has the highest 2, 3 and 5 year average at the Ritzville WSU Variety Testing location. Masami also constantly performs extremely well in the Oregon State Winter Elite Yield Trials.

**Bruehl**, released from this project in 2002, was the top white club variety in the state for the 7th straight year. It was produced on over 72% of the club acres in 2008 (2008 WA Ag Stats) which is nearly 3 times as many acres as all the other clubs in the state combined.

The Washington Agricultural Statistics Service reported for 2008 that **Bauermeister**, in its second year of commercial production, was once again the top hard red winter (HRW) variety in Washington with 74,700 acres planted. They also reported that the top three varieties produced (Bauermeister, Finley and Buchanan) were out of the WSU Winter Wheat program and accounted for over 55% of the HRW acreage.

The WSU Extension Uniform Variety Testing Program's hard winter wheat trials ranked **WA008067** and **WA008068** as two of the top 5 yielding HRW varieties with statewide mean yields of 74.3 and 70.6 bu/a, respectively. Bauermeister was ranked #6 with a mean statewide yield of 70.4 bu/a. All of the WSU HRW varieties met or exceeded minimum protein requirements (11.5%) at every HRW WSU Variety Testing location.

**MDM**, at 71.5bu/a, was the top yielding hard white winter (HWW) wheat statewide with a mean protein level of 11.9%.

### USDA-ARS Club Wheat Breeding

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Club wheat acreage increased to 190,000 acres in Washington for 2008. Approximately 300 crosses were made to incorporate new sources of resistance to stripe rust into spring and winter breeding lines. We also developed winter and spring wheat populations to study the inheritance of stripe rust resistance. In the breeding program our crosses were to create populations with resistance to barley yellow dwarf virus resistance, cold tolerance, Cephalosporium stripe, Fusarium crown rot, stripe rust and pre-harvest sprouting. Marker assisted selection is used routinely to select for resistance to stripe rust, barley yellow dwarf virus resistance, Hessian fly and strawbreaker foot rot. We evaluated over 47,633 winter wheat plots and head rows in 11 locations in WA, ID, and OR in 2008, similar to previous years. We continue to increase our spring wheat breeding effort, specifically to introgress new sources of stripe rust resistance into spring wheat. For 2009, five breeding lines were entered into the Washington State Cereal Variety trials including the club wheats: ARS970075-3C, ARS970168-2C, and ARS970071-3C; and the soft white wheats: ARS960277L and ARS97170-2L. ARS97075-3C has high test weight, and ARS970168-2C is short and early relative to current cultivars. ARS970168C and ARS960277L both had yields that were greater than Eltan, Chukar, and Tubbs at our testing locations while yields of the other two lines were

comparable to Tubbs. In addition, ARS970075-3C and ARS960277L have been approved for pre-release and purification will begin this summer in collaboration with the Washington Crop Improvement Association. ARS970075-3C is an intermediate height semi-dwarf wheat with awned compact (club) spikes and white chaff and white glumes and ARS960277L is an intermediate height semi-dwarf wheat with awned lax spikes and white chaff and white glumes. They both bring pedigree diversity, competitive yielding ability, excellent test weight, intermediate maturity and height, excellent resistance to stripe rust and strawbreaker foot rot, and excellent grain end-use quality and grain grading characteristics compared to the currently grown wheat cultivars, Bruehl, Chukar, Coda and Cara, Eltan, Madsen, Tubbs and Xerpha. They are both targeted to the intermediate to high rainfall (>12 inch average annual precipitation) production zone as a compliment to Chukar, Cara, Tubbs06 and Xerpha and to replace some acreage of Coda, Madsen and Eltan. The maturity of both lines is 2 days later than Tubbs, earlier than all other club wheat cultivars. We have made significant progress in breeding earlier maturing high yielding club wheat breeding lines with the traditional excellent club wheat quality.

## Improving Spring Wheat Varieties for the Pacific Northwest

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In 2008, the soft white spring (SWS) variety **Louise** (released in 2005) was grown on more than 155,000 acres, representing 52% of the total soft white common spring wheat acreage in Washington State. Due to its high grain yield potential, superior high-temperature, adult-plant (HTAP) resistance to stripe rust, partial resistance to the Hessian fly (HF), and improved emergence, Louise has displaced a significant portion of the Alpowa and Nick acreage in intermediate and high rainfall zones. Grain yields of Louise equaled or exceeded those of Alpowa and Nick in a majority of the non-irrigated field trial evaluations conducted from 2001 to 2008. The end-use quality of Louise is superior to that of Nick and Alpowa.

**Whit** (formerly WA8008), another SWS, was officially released in 2008, and is targeted for production in high rainfall areas in Whitman and Latah counties. Whit has excellent yield potential in the target production region that equals or exceeds that of Louise; however, Whit matures earlier and is shorter in plant height compared to Louise. Whit is HF resistant, has moderate levels of HTAP resistance, and has excellent milling and baking qualities. We anticipate that Whit will replace significant portions of the Louise, Nick and Alpowa acreages in high rainfall zones.

**Babe** (formerly WA8039) is a new SWS wheat that was approved for release in 2009. Babe has excellent grain yield potential, high test weight, excellent milling and baking quality and high levels of HTAP resistance to stripe rust. Babe is intended as a replacement for Alpowa in the low to intermediate rainfall zones based on its improved emergence and higher levels of HTAP resistance. **JD** (formerly WA8047) is a new spring club variety that was approved for release in 2009. JD is a broadly adapted, high yielding variety with excellent race-specific, all-stage and HTAP resistance to stripe rust. It also has outstanding milling and baking quality. JD is intended as the stripe rust resistant replacement for Eden in all rainfall zones.

**WA8090** is a new SWS wheat approved for pre-release in 2009 that is the most promising spring wheat variety release candidate identified from this program in the last 14 years. WA8090 has several remarkable features including: 1) outstanding grain yield potential across a broad range of production environments; 2) high test weight; 3) outstanding end-use quality; 4) HF resistance; and 5) high levels of HTAP resistance to stripe rust. WA8090 may be an excellent option in the low rainfall zone where the low test weight of Louise can be a concern. Its broad adaptation range overlaps with the target production areas of both Whit and Babe, which will expand variety options for producers in these areas.

Since 2006, more than 54,000 acres of **Tara 2002** (released in 2000) were produced in Washington State. Tara 2002 was originally targeted to the intermediate to high rainfall zones as a replacement for WestBred 926. Tara 2002 is early maturing, is moderately resistant to stripe rust and the HF, and has outstanding end-use quality. The unique quality attributes of Tara 2002 resulted in the development of an identity preserved market for this variety. Tara 2002 is used in a flour blend called The Shepherd's Grain, which is sold by Columbia Plateau Producers to local and regional clientele, including WSU Dining Services. **Hollis**, a 2003 release, was grown on more than 35,000 acres in 2008, representing 12 percent of the hard red spring acreage in Washington State. Hollis acreage has nearly tripled since 2006, and all of these acres are in the Central and East Central growing regions of the state.

**Kelse** (formerly WA7954) was officially released in 2008, and is the first hard red spring wheat variety developed by our program with excellent race-specific, all-stage resistance and HTAP resistance to stripe rust. Kelse is well adapted to the high rainfall zone, and has exceptionally high grain protein content compared to other hard red spring wheat varieties currently in commercial production. It also is 100% resistant to the HF. Kelse is targeted for production in the intermediate to high rainfall zones as a replacement for WestBred 926, Hank and Tara 2002.

## Application of Biotechnology to Spring Wheat Variety Improvement

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Biotechnology is useful for identifying superior breeding lines in early generations of selection that carry genes deemed as essential for commercial success prior to field evaluation. Our goal is to use marker-assisted selection (MAS) to introgress target gene(s) into adapted germplasm quickly and efficiently. We used this strategy to incorporate *Yr5* and *Yr15*, two seedling resistance genes to stripe rust that have not been circumvented by any race of the pathogen found in North America to date, into adapted cultivars such as Scarlet (HRS), WA7900 (HWS), Zak (SWS) and Alpowa (SWS). We also are using MAS to pyramid these seedling resistance genes with high-temperature adult-plant (HTAP) resistance and Hessian fly (HF) resistance genes *H3*, *H9*, and *H25*. Screening of segregating F<sub>2</sub> breeding populations using markers was initiated in December 2008, which facilitated pyramiding seedling, HTAP, and HF resistances into single experimental breeding lines. Over 500 F<sub>5</sub> headrows with varying combinations of these genes will be planted in the spring of 2009 for phenotypic evaluation. Simultaneously, lines carrying targeted genes will be utilized as crossing parents in forward breeding strategies. Three cultivars, Louise, Whit and WA8010 (HWS) were indentified as candidates for enhancing their level and durability of stripe rust resistance. Using MAS, along with our rapid breeding method in the greenhouse, more than 4,500 breeding lines were evaluated in 2008, resulting in 217 lines being selected for advancement to 2009 field trials. A high grain protein content gene, *Gpc-B1*, from the hard red spring wheat variety Glupro, was incorporated into the hard red winter line WA7869 using MAS. WA7975, a backcross derivative of WA7869, which carries *Gpc-B1* was released as Farnum in 2008. Farnum is a tall, late maturing hard red winter wheat variety developed in collaboration with Drs. Kim Campbell and Steve Jones.

## Artificial Freeze Testing of Winter and Spring Wheat: Evaluation of Released and Experimental Germplasm

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Winter injury is a common risk factor for wheat production in the Pacific Northwest. Large variation in freezing temperatures, soil conditions, and snow pack exists in PNW breeding nurseries and production fields; therefore, an artificial freeze experiment was designed and implemented to test the cold tolerance of cultivars and breeding lines in a controlled environment with uniform soil conditions and plant growth stages. The lines are grown for seven days, vernalized for five weeks, and then exposed to a 24 hour freeze cycle in a programmable freeze chamber at the Plant Growth Facility at WSU where the minimum temperature during testing is -12C for winter wheat and -6C for spring wheat. Every two minutes during the freeze cycle, exact soil temperatures are collected from the roots of plants using temperature probes connected to data collection software. After freezing, the plants are grown at standard greenhouse temperatures for five weeks. Survival percentages, called Lethal Temperature at 50% (LT-50) values, are then recorded and compared with the LT-50 values of other cultivars with similar traits, to single out genes contributing to cold tolerance. The LT-50 values have shown good correlation with winter survival over the past six years of observations in the wheat variety trials at Spillman Agronomy Farm and other Washington locations. Each year the Washington Variety Trials Hard and Soft Winter and Spring Wheat, Western Regional Cooperative Hard and Soft Winter Wheat Nurseries, and WSU and USDA-ARS breeding lines are evaluated for cold tolerance. This year we have included the world collection of cold tolerant wheat cultivars and two mapping populations. The goal of these evaluations is to identify cold tolerant cultivars and lines that can be incorporated into breeding programs in order to increase and stabilize yields through resistance to cold.

## Improving Seedling Emergence in Winter Wheat

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Water use efficiency is the most important factor for dryland farming, including the 2.0 million dryland farm acres of Eastern Washington, receiving less than 10 inches of annual precipitation. Winter wheat is planted deep into tilled summer fallow and farmers need varieties that can emerge quickly. Successful stand establishment from late summer planting directly affects grain yield and water use efficiency in this region. Most of the semi-dwarf cultivars in PNW contain Rht1 and Rht2 dwarfing genes that have an adverse effect on coleoptile length and thus impede seedling emergence. We have been funded by the Washington Wheat Commission to improve the emergence of the new semi-dwarf soft winter wheat variety Xerpha. Four approaches are being taken for this project. First we are testing the emergence of the available dwarfing mutant lines, or other material known to increase coleoptile length, under simulated PNW dryland conditions. Valuable material will be used as a donor parent. Secondly, we have collected 700 wheat cultivars from across the globe to capture variation in coleoptile length in wheat. Analysis of 250 of these lines has shown a coleoptile length variation of 39 mm to 103 mm. Lines with the longest coleoptiles will be used as alternate donors. Third, seeds of soft white wheat variety Indian were treated with 30mM, 40mM, and 50mM of EMS with the objective to generate mutants in dwarfing genes other than the currently used Rht genes. The mutagenized heads from greenhouse will be space planted in the field as head-rows for selecting the dwarf mutants. Fourth, the cultivars Moro (soft white club) and Buchanan (hard red common) are being used as good emergence donors in the interim to transfer that trait into Xerpha. The initial crosses have been made and the backcrossing experiment is in progress.

## Breeding for Plant Parasitic Nematode Resistance in Wheat

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Plant parasitic nematodes are important soil borne pests that have been linked to major crop damage resulting in economic loss. Second to fungi, nematodes are one of the oldest characterized parasites of wheat. *Pratylenchus* spp., common name root-lesion (RLN), has been associated with wheat yield loss worldwide including the Pacific Northwest. In semi-arid dryland agriculture *Pratylenchus thornei* and *P. neglectus* species are considered the most important. Several surveys have detected *P. thornei* and/or *P. neglectus* in 90% of sampled fields in the PNW. Yield loss of intolerant cultivars caused by *P. thornei* and *P. neglectus* has been reported at 50% and 37% respectively in these growing regions. Using resistant cultivars in crop rotations is considered the simplest and most convenient method for controlling nematode populations. The objectives of our research is 1. To identify the number and location of loci for resistance to *Pratylenchus* spp in the Iranian land race AUS28451. 2. To characterize resistance to *P. neglectus* in a set of Iranian landraces previously selected for resistance to *P. thornei* and 3. To characterize differences in expression patterns of wheat genes in nematode resistance and susceptible cultivars using microarray analysis. For objective 1, we are developing recombinant inbred and doubled haploid mapping populations from a cross between AUS28451 by the susceptible locally adapted cultivar Louise, F3 RILs are currently being grown. Doubled haploid development will be done during the summer of 2009. For objective 2, we are constructing nematode extraction facilities, have increased seed of the landraces and will begin evaluation during the fall of 2010. The results of this research will provide locally adapted germplasm with improved nematode resistance, new molecular markers that can be used to select for that resistance, as well as new exotic sources of resistance to multiple *Pratylenchus* species.



## Transferring Two-gene Clearfield Technology into PNW Varieties

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Winter grass weeds and stripe rust are the two major problems of the Pacific Northwest (PNW) in US that lead to significant reductions in grain yield and end use quality of cultivated wheat. One of the efficient solutions to this problem is the development of genetically improved wheat varieties harboring genes providing resistance to various diseases and herbicides. In view of that significant progress has been made in this direction and a number of herbicide tolerant or Clearfield varieties have been released. Unfortunately, none of the varieties available so far carry more than one gene for herbicide tolerance. Incorporation of two genes in a single genotype through traditional backcrossing is not an easy task. Therefore, we undertook a marker assisted background selection (MABS) scheme to transfer 'Clearfield' herbicide tolerance genes into Washington wheat cultivars. We have targeted three classes of wheat cultivars including winter (Eltan, Madsen, Rod and Xerpha), spring (Louise) and club (Chukar), to transfer two-gene Clearfield resistance. Using the above scheme, now we have transferred the two-gene Clearfield technology into winter wheat varieties Eltan, Madsen and Rod. Two of the Rod derivative lines (KCF08001 and KCF08002) are currently in WSU variety testing program. After phenotypic screening and analysis with ~1200 markers, of about 5000 plants per target, the Eltan and Madsen derived lines are currently being grown in the greenhouse to seed increase for WSU variety testing for the growing season of 2009-2010. In order to select for plants with superior grain yield and quality, greenhouse screening for grain yield and single plant quality estimation via Solvent Retention Capacity (SRC) test, grain hardness, grain protein content and other traits were optimized. It would be interesting to study the correlation between the greenhouse and field data for the yield and quality characteristics. Our next targets for the two-gene transfer for the Clearfield technology are Xerpha, Louise and Chukar. In addition to recovering Xerpha type plants, we will optimize and apply our forward breeding approach to improve Xerpha's quality as well. Similarly, the forward breeding approach will be applied to recover yield and stripe rust resistance comparable to that present in some of the newly released spring wheat cultivars.

## Mapping of *Yr5* and *Yr15* Stripe Rust Seedling (All-stage) Resistance Genes

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Two major genes for resistance to stripe rust, *Yr5* and *Yr15*, currently provide complete resistance to all known lines of stripe rust in the US. *Yr5* and *Yr15* have been previously located on (2B and 1B, respectively). Molecular markers have been identified for both genes, but, unfortunately, those markers are frequently not polymorphic in germplasm in breeding programs from the Pacific Northwest. Better markers would greatly facilitate our efforts to put these two genes together with durable adult plant resistance in breeding lines and cultivars. Our objective was to re-map the two genes using data from a combination various molecular marker types including SSR, RGAP, and STS markers. We mapped the markers and the stripe rust resistance trait in two recombinant inbred lines mapping populations, one derive from a cross between Avocet-*Yr5* and Avocet-Susceptible (S) and the other from a cross between Avocet-*Yr15* and Avocet-S. We mapped 11 SSR and 1 STS loci to chromosome 2B in a 26.4cM region flanking *Yr5*. A total of 8 SSR and 1 STS loci were mapped to chromosome 1B in a 5.9cM region flanking *Yr15*. Three markers, wpg34, gwm413, and Barc8 were completely linked with *Yr15*. Markers barc167, barc349, and wmc175 flanked *Yr5*. To verify the polymorphic nature of the closest linked markers based on the developed map, we tested germplasm from various breeding programs throughout the US with different genetic backgrounds and found that at least one of the markers for each gene was diagnostic. These maps will enable more efficient marker assisted selection of these genes with several marker choices.

## Breeding Wheat for Association with Mycorrhizal Fungi

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Wheat yields on marginal soils and in low-input systems are limited by available soil nutrients and the plants' ability to access those nutrients. In particular, phosphorus is limiting in areas that have low organic matter or have undergone severe erosion. Mycorrhizal fungi are a class of beneficial fungi that are known to associate with wheat. These fungi can access large volumes of soil to deliver micronutrients, phosphorus and water to plants in exchange for carbon supplied by the plant roots. While there is some evidence that there are varietal differences for the ability of wheat to benefit from mycorrhizal symbiosis, this has not been widely investigated. The objective of this research is to identify wheat varieties that have improved yield, biomass production, and uptake of soil nutrients due to mycorrhizal associations. Twenty-eight different cultivars that represent different production regions in the world and different responses to root pathogens, drought and management parameters are being evaluated in a greenhouse trial. Seedlings were inoculated with the commercial inoculant Micronized Endo® (Mycorrhizal Applications, Inc., Grants Pass, OR) and grown in a low phosphorus soil in greenhouse for five weeks. Mycorrhizal colonization, shoot and root biomass and leaf nutrient concentration will be assessed, A similar field experiment is underway using five different wheat varieties in three locations: Bickelton, Lind and Benge, Washington. Wheat varieties that can effectively exploit the advantages of mycorrhizal colonization without a reduction in plant performance will be identified for further study and breeding.

## WSU Extension Variety Trials – Bringing Variety Selection Technology to Growers

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The WSU Extension Uniform Cereal Variety Testing Program provides growers, the agribusiness industry, university researchers, and other interested clientele with comprehensive, unbiased information on the adaptation and performance of small grain cultivars across the climatic regions of eastern Washington. The Variety Testing Program conducts comparisons using scientifically sound methodology, produces unbiased results, disseminates all data to clientele, and uses uniform testing procedures; uniform testing means that trials are performed the same at all locations. The replicated Variety Testing Program evaluation trials in the dryland and irrigated production areas of eastern Washington are conducted at many locations: 21 for soft white and 11 for hard red winter wheat; 14 for soft white, hard red, and hard white spring wheat; and 11 for all classes of spring barley. Trial results are available in printed form in: Wheat Life, the Cereal Variety Evaluation Annual Report, summarized in the WSCIA Certified Seed Buying Guide, and comprehensive results for the current year and several previous years are on the Variety Testing Web site (<http://variety.wsu.edu>). Oral presentations, field days, and industry and extension meetings are other means used for delivering research results. Results from the Extension Variety Testing Program provide unbiased measures of variety performance to support variety selection decisions by growers and for other decisions by other clientele. Growers can realize a timely economic payback using information from yield and variety performance data that is provided within days after harvest via an email list-serve. This project is made possible by contributions of land and time from farmer cooperators where trials are located, and cooperators at the WSU research units at Pullman and Lind. Partnerships with research scientists from public and private sectors are vital to make this program successful. Funding is provided by: Washington Wheat Commission, Washington Barley Commission, WSU Agricultural Research Center, Washington State Crop Improvement Association, and private companies that enter varieties into the trials.



## Regional Cooperative Testing in the Western Regional Uniform Wheat Nurseries

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COOPERATORS IN CA, CO, ID, MT, OR, WA, UT,

The goal of the Western Regional Uniform Wheat Nurseries are to evaluate advanced winter and spring wheat germplasm for agronomic, disease and insect resistance; and to test end-use quality characteristics of wheat produced in diverse production regions throughout the Western United States. The nurseries function as an important vehicle for the exchange of advanced breeding lines among breeders in both the public and private sector. The USDA ARS Wheat Genetics Unit is responsible for the coordination and dissemination of this information and annually produces the Western Regional Uniform Cooperative Wheat Nurseries Report. This involves 4 individual nurseries (Hard Winter, Soft Winter, Hard Spring, and Soft Spring) grown in 23 locations over 6 states by 12 cooperators. There are over 50 individual agronomic trials included in the annual report. In addition, there are disease ratings from on stripe rust, dwarf bunt, stem rust and leaf rust obtained from trials conducted by the USDA ARS labs in Aberdeen, ID, St. Paul, MN, and Pullman, WA; as well as the country of Kenya. End use quality data are assayed at the Western Wheat Quality lab in Pullman, WA. Beginning in 2008, genotype data from molecular markers associated with several important agronomic and disease traits was assessed on all nurseries by the USDA-ARS Western Regional Small Grains Genotyping Laboratory. This is a cooperative effort utilizing the skills and expertise of Breeders, Pathologists, and Cereal Chemists nationally and internationally. This shared information is an important tool used by wheat breeders to determine the viability and adaptability of diverse germplasm before potential release into the commercial wheat markets. This information can be accessed at the following website: <http://www.ars.usda.gov/Services/docs.htm?docid=3712>

## USDA-ARS Western Wheat Quality Laboratory

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C MORRIS, USDA-ARS WESTERN WHEAT QUALITY LABORATORY, PULLMAN, WA

The mission of the USDA-ARS Western Wheat Quality Lab is two fold: conduct milling, baking, and end-use quality evaluations on wheat breeding lines, and conduct research on wheat grain quality and utilization. Our web site: <http://www.wsu.edu/~wwql/php/index.php> provides great access to our research. Our research publications are available on our web site. Our current research projects include grain hardness, puroindolines, waxy wheat, polyphenol oxidase (PPO), arabinoxylans, SDS sedimentation test, and wheat ash. Our recent publications include studies on genotype and environment variation for arabinoxylans in hard winter and spring wheats of the U.S. Pacific Northwest, and the identification of differentially expressed UniGenes in developing wheat seed using digital differential display. Two reviews on the molecular genetics of puroindolines and related genes were published. Other studies included the silencing of puroindoline a which alters the kernel texture in transgenic bread wheat, and the prevalence of puroindoline alleles in wheat varieties from eastern Asia including the discovery of a new SNP in puroindoline b, and the cloning and phylogenetic analysis of polyphenol oxidase genes in common wheat and related species. The reconciliation of D-genome puroindoline allele designations with current DNA sequence data was published, and hard kernel puroindoline allele near-isogenic lines in Alpowa were developed and registered. Recent wheat varieties that have been developed in collaboration with WSU, OSU and USDA-ARS scientists include Babe, Cara, Diva, Farnum, JD, Kelse, ORCF-103, Skiles, Tubbs 06, Whit, and Xerpha.

## End-Use Quality Assessment of WSU Wheat Breeding Lines, and Starch Properties of Hard and Soft Wheat Genotypes

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The goal of the WSU Wheat Quality Program (WSUWQP) is to increase the competitiveness of Washington wheat in the global market by developing wheat varieties possessing desirable end-use quality characteristics. We facilitate early and late generation quality testing of WSU breeder lines; develop new procedures that target specific end-use products and predict end-use quality in early generations and communicate end-use quality issues

to growers. For the crop harvested in 2007, we tested approximately 1194 samples from the WSU spring and winter wheat breeding programs in conjunction with the Western Wheat Quality Lab. The end-use quality evaluation data have been used by the breeders for making selections of their breeding lines for the next growing season. The data and information we are generating are essential for developing new wheat varieties possessing superior and consistent quality attributes. Since its inception in 2000, the WSUWQP has contributed to the release of 12 new varieties in all market classes grown in Washington.

Thermal properties of starch, including gelatinization, pasting and retrogradation, significantly affect processing, cooking and textural quality as well as shelf life of many wheat-based food products. To explore the differences in functional properties of starches among various classes of wheat, we isolated starches from wheat genotypes of contrasting classes including regular and partial-waxy wheat, hard and soft, and white and red. In both regular and partial-waxy genotypes, soft white (SW) wheat showed lower starch damage, pasting temperature and peak viscosity than hard white (HW) wheat. SW wheat genotypes produced harder gel than hard white (HW) wheat among regular starch genotypes. HW wheat exhibited greater pasting temperature than hard red wheat genotypes. Starch damage was positively related with pasting temperature and peak viscosity within each starch type. This research helps define starch properties for better understanding of end-use quality parameters.

## Marker Development and Marker-assisted Selection for Improved Pest Resistance and End Use Quality in Pacific Northwest Wheat

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A primary goal of most public wheat breeding programs is to implement marker-assisted selection (MAS) for useful complex traits. U.S. wheat researchers have developed protocols for more than fifty molecular markers for resistance genes and quality traits and have used these markers to incorporate valuable genes in the best breeding lines from ten different market classes. In Washington, the spring and USDA wheat breeding programs are introgressing genes for resistance to stripe rust, barley yellow dwarf virus resistance, resistance to Fusarium crown rot, Hessian fly resistance, and for high grain protein content. In addition we created a mapping population from a Louise/Penawawa cross to analyze complex traits in the Pacific Northwest (PNW). We have identified a major quantitative trait locus (QTL) for high-temperature adult-plant (HTAP) resistance on chromosome 2BS, originating from the resistant parent Louise. Molecular markers Xwmc474 and Xgwm148 flank this QTL and have been used in early generation selection to introgress this QTL into other germplasm. In addition, molecular markers for the Hessian fly resistance gene H3, also originating from the resistant parent Louise, have been identified. These markers have been used to incorporate Hessian fly resistance into spring wheat lines, as well as to pyramid this gene with other Hessian fly resistance genes, thereby enhancing the durability of resistance. Preliminary end-use quality data from this mapping population was used to identify many putative QTL for end-use quality traits, which we hope to confirm using 2008 data. QTL results will be used to begin to dissect the complexity of end-use quality traits in wheat. Forward breeding strategies involving the use of markers associated with important QTL are being used to speed up the incorporation of essential genes into improved wheat cultivars for the region.

## Barley Improvement for Washington and the PNW

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S.E. ULLRICH, V.A. JITKOV, M.B. WOOD, H. LEE, AND S.G. NAIR. COLLABORATORS: A. KLEINHOF, D. VON WETTSTEIN, S.O. GUY, X. CHEN, T.C. PAULITZ, B.-K. BAIK, I. BURKE, J. YENISH WITH RESEARCH ASSOCIATES, TECHNICIANS AND/OR GRADUATE STUDENTS, DEPT. OF CROP AND SOIL SCIENCES, WSU

The overall goal of the WSU Barley Improvement Program is to make barley a more profitable crop. Specific objectives are to improve agronomic, adaptation, and grain quality factors for primarily dryland production. The emphasis is on spring 2-row barley for feed, food, and malting use. A mix of classical and molecular methods is used to solve barley genetics puzzles and to breed improved cultivars. The two most recent WSU releases, 'Bob' and 'Radiant' are well adapted to the dryland growing conditions in eastern Washington. Based on results through 2008 from the Extension State Uniform Nursery, both Bob and Radiant (>100 loc.-yr) yielded 99% of Baroness, and over the last 2 years yielded 105% of Baroness. Yields were statistically equal or greater than Baroness at individual locations. Five advanced breeding lines yielded over 100% of Baroness in 2008 with



04WNZ-124 yielding 108% of Baronesse. These lines show promise for release. Two hulless waxy lines, WA9820-98 and 01WA13860.5, are release candidates to be directed at food and feed use. Food barley demand is on the rise in part due to the FDA "Heart Healthy" endorsement. Novel trait combinations bred include hulless + waxy + proant-free for food products and hulled + waxy for grain fractionation and ethanol production. Other research involves molecular genetic mapping of dormancy, preharvest sprouting, grain hardness and malting quality genes and molecular breeding for malting barley improvement. Combining the high yield of Baronesse and high malting quality of Harrington using molecular marker-assisted selection has yielded several promising breeding lines. Collaboration in the Barley Cooperative Agricultural Project (CAP) involves molecular genetic tools for association mapping of important traits and high-throughput marker identification and marker-assisted selection for barley improvement. Evaluation of barley grain for food use and plant resistance to selective herbicides and *Rhizoctonia* root rot is underway.

## Transgenic Barley on Spillman Farm

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This year's trials comprise the following material:

1. Long term yield nursery of barley containing (1,3;1,4)- $\beta$ -D-glucanase enzyme.
2. Breeding herbicide sensitive barley containing (1,3;1,4)- $\beta$ -D-glucanase enzyme
3. Breeding herbicide sensitive barley expressing human lactoferin or lysozyme

**Converting barley from a low energy feed to a high energy feed.** The low nutritional value of barley for poultry is due to the absence of an intestinal enzyme for efficient de-polymerization of (1,3;1,4)- $\beta$ -D-glucan, the major polysaccharide of the endosperm cell walls. This leads to high viscosity in the intestine, limited nutrient uptake, decreased growth rate, and unhygienic sticky droppings. Broiler chicken trials have shown that transgenic grain expressing protein-engineered thermostable (1,3;1,4)- $\beta$ -glucanase as feed additive can increase the nutritive value of barley based diets to that of maize. With a barley-soybean diet containing 620 g non-transgenic barley/kg diet, it was sufficient to add 0.2g (0.02%) transgenic grain/kg diet to achieve the high nutritive value. The transgene has been bred into modern barley varieties. With these lines a yield has been achieved that compares favorably with that of Baronesse. Present improvement of the cultivars is carried out by selecting herbicide sensitive lines.

**Barley producing human lactoferin or lysozyme.** Infants who are breast-fed are frequently healthier and contract fewer infections than those who are given baby-food formula. Breast-fed babies develop healthier because mother's milk contains proteins that efficiently support newborns to avoid infections and disease. Prominent among these are lysozyme and lactoferin, which are present in larger amounts in human milk than e.g. cow milk. We have produced transgenic barley expressing these two proteins to be used in infant food. Present breeding efforts are directed to obtain good producers of the proteins and herbicide sensitivity.

## Grain Hardness Variation in Barley Lines and its Influence on Food Processing

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S. NAIR, B. BAIK, S. ULLRICH, DEPT. OF CROP AND SOIL SCIENCES, WSU

Barley is a significant source of dietary fiber especially soluble fiber called  $\beta$ -glucans that have been clinically proven to be effective in lowering cholesterol and glycemic index. Despite its remarkable nutritional benefits, barley is still one of the most underutilized cereal grains for human food. Recent FDA endorsement of barley health food claim has rekindled interest in barley as food source. Due to limited use of barley for food, there is a lack of experience in breeding and cultivating food barley varieties. Identification of food use traits of barley and establishment of screening methods are crucial for development of food barley lines. Grain hardness of barley may influence pearling and milling properties, flour particle size distribution, and product quality, as well documented in wheat, a close relative of barley. Unlike in wheat, not much is known about the basis of grain hardness in barley. The objectives of our research include studying variation in USA barley lines and its significance on food processing. Grains of 959 breeding lines of various classes contributed by ten major barley

breeding programs as part of the USDA funded Barley CAP were evaluated for hardness (HI) using a single kernel characterization system (SKCS). Overall, barley showed tremendous variation in HI ranging from 30.0 – 91.8. Ten barley lines of varying HI (30.0 – 91.8) were selected to determine the influence of grain hardness on pearling rate, particle size distribution, water absorption, cooked kernel texture and starch damage. Pearling rate negatively correlated with HI ( $r = -0.87^{**}$ ), suggesting that pearling rate decreases as grain hardness increases. % water absorption by barley kernels and cooked kernel texture showed no significant association with HI. HI showed a significant positive correlation ( $r = 0.93^{***}$ ) with flour particle size, indicating that harder kernels produce more coarse particles during milling than softer kernels. % starch damage showed a significant positive correlation with HI ( $r = 0.93^{***}$ ). Overall, these results show that wide variation in grain hardness exists in the USA barley lines and that hardness is an important functional trait for food processing and end-use quality. Other studies with lines varying in HI focus on grain anatomical differences, genetic analysis, and role of the growing environment.

## USDA-ARS Grain Legume Genetics and Physiology Research Unit

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The USDA-ARS Grain Legume Genetics and Physiology Research Program annually conducts advanced and preliminary yield trials on lentils, chickpea and dry pea at Spillman Farm. These cool season food legumes play an important role in cropping systems in the Palouse, in that they are typically used in rotations with small grains such as wheat and barley. Growing cool season food legumes breaks up disease cycles of pathogens of small grains and also provides nitrogen to subsequent small grain crops through fixation of nitrogen by *Rhizobium* and *Metarhizobium* bacteria that colonize the roots of lentils, peas, and chickpeas. Traits that are considered important for improved varieties of lentils, peas, and chickpeas include high yield, disease resistance, tall plant height, and tolerance to lodging.



In 2009, the advanced lentil trials include 12 Eston-type lines, 18 Pardina-type lines, 12 Turkish Red lines, 8 zero-tannin lines, and 22 large seeded green lines. Of particular interest are lines LC01602273E, an Eston-type lentil that historically out yields the commercial cultivar Eston by over 20%, and LC01602300R, a large seeded green lentil that out yields the commercial cultivar Merrit by 20%. The advanced chickpea yield trials in 2009 include 24 kabuli lines, consisting of 20 café colored lines and 4 Spanish white lines. Of particular interest are lines CA0469C025C, a small seed café chickpea, and CA04900843C, both of which out yield the commercial cultivar Dwelley by over 30%. The advanced pea yield trials in 2009 include 20 different lines, consisting of both green and yellow peas. Of special interest is line PS03101822, a yellow pea that out yields the commercial cultivar Delta by 10%. Disease nurseries to screen lentils, peas and chickpeas for resistance to Ascochyta blight, Fusarium wilt, and Aphanomyces root rot are also located at Spillman Farm.

## Optimizing Nitrogen Fixation by Crop-Rhizobial Interactions in Peas and Lentils

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Nitrogen fixation in legumes requires symbiotic interaction of plants with rhizobia bacteria. Increasing this N fixation could both increase crop productivity and reduce fertilizer costs. Optimizing this symbiosis may require

improving selections of each partner of the symbiosis. In this study five varieties of lentils and five varieties of peas were tested with 13-15 commercial strains of *Rhizobium leguminosorum* bv. *Viciae* to determine both better strains for inoculation and varieties with high potential as breeding lines.

Inoculated plants were grown for 6 weeks. Below and above ground biomass, numbers of nodules, and the proportion of plant N provided by fixation were determined. All plant parameters were positively correlated to N fixation. The N fixed in lentils was significantly influenced by both crop variety and rhizobial strain. Eston and Meritt varieties fixed the highest amount of N respectively at 80.8% and 80.5%. In peas the amount of fixed N reached 91.3 % and 90.5% respectively in Shawnee and Bohatyr, and different strains had no effect on the amount of N fixation.

Lentil Variety	% Fixed N	% Strains providing > 70% N	Root Nodules Per plant
Eston	80.9a	100	26a
Meritt	80.5a	100	19ab
Pardina	74.8ab	92	16b
Pennell	76.9ab	69	13b
Riveland	70.7b	61	16b
P value	0.0013		0.0041
Pea Variety	% Fixed N	% Strains providing > 90% N	Root Nodules Per plant
Bohatyr	90.5ab	46	18ab
Delta	88.7abc	26	21a
Lifter	87.2c	13	14ab
Medora	87.5bc	13	14b
Shawnee	91.3a	80	18ab
P value	<0.0001		0.028

Legume varieties had a significant influence on N fixation suggesting that crop breeding to support higher rates of N fixation may be possible. We are now pursuing funding for this purpose in collaboration with the USDA-ARS Grain Legume Genetics researchers.

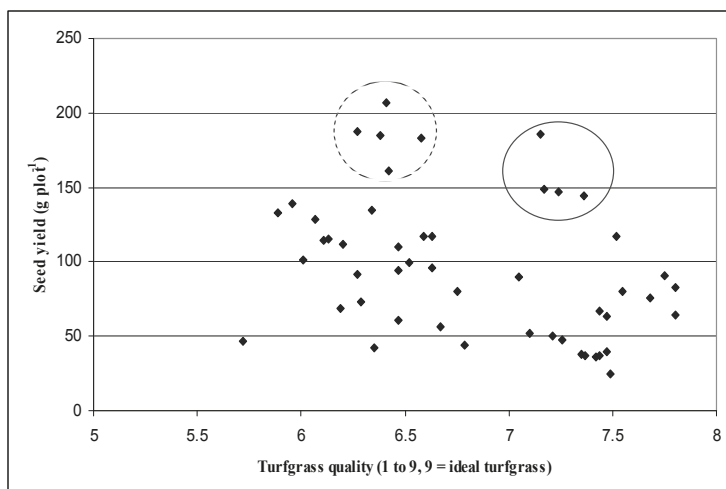
## Kentucky Bluegrass Germplasm for Non-burn Seed Production

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This long-term study consists of 10 Kentucky bluegrass (*Poa pratensis* L.) entries; eight are PI accessions and two are commercial check cultivars ('Kenblue' and 'Midnight'). The selected PI accessions represent a range of responses to residue treatments. Several agronomic yield parameters were evaluated over a 2-yr period and individual plants were selected within each accession or check with the highest seed weight, highest seeds per panicle, highest panicles per unit area, and highest yield. These were planted into a seed increase nursery at Central Ferry, WA in late fall 2004. The seed increase nursery was harvested in June 2006 and 2007 and seed was planted in turf plots in 2006 and seed production plots in 2007 at Pullman.



The turfgrass trial was evaluated monthly (2007 and 2008) according to National Turfgrass Evaluation Program protocol to determine rate of establishment, overall turf quality, color, texture, chlorophyll index, and spring green-up. In 2008, seed production plots were evaluated for seed yield, seed weight, yield per plant, seed per panicle, and panicle number per area. The selection for seed yield components had a variable response and appeared to be dependent on accession. Two accessions, PI 371775 and PI 368241, show promise of being able to provide good turfgrass quality and also good seed yield under non-burn conditions (Fig. 1). These studies will be followed for several harvests to determine if a non-burn Kentucky bluegrass can be developed for sustainable grass seed production in the Pacific Northwest.

## Part 2. Pathology and Entomology

### Strawbreaker Foot Rot, Cephalosporium Stripe, and Snow Mold Diseases of Winter Wheat

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Strawbreaker foot rot (eyespot) and Cephalosporium stripe are important diseases of winter wheat in the Pacific Northwest occurring on 1.3 to 1.8 million acres in Washington State. These diseases are economically important with potential loss in grain yield up to 50% for eyespot and up to 80% or more where Cephalosporium stripe is severe. Both diseases are most common in areas with more than 18" annual precipitation, but can cause significant losses in lower rainfall areas too. Early-seeded winter wheat has the greatest risk of being affected by these diseases, especially when planted following summer fallow.

Fungicide applications in the spring before jointing or planting a resistant variety like Madsen are the main controls for eyespot. Disease-resistant varieties remain the most desirable and least expensive method for controlling eyespot. Collaborative research with Dr. Jones' winter wheat breeding program has resulted in transfer of true resistance from wheatgrass into wheat and these lines are being used as parents in the breeding program.

The snow molds occur in the north-central wheat-producing area of eastern Washington, where snow cover can persist for more than 100 days. Snow molds can cause complete yield loss in years when they are severe. Disease resistant varieties and early seeding are the best control methods for the snow molds. Bruehl and Eltan are currently the most popular varieties where snow mold is of concern.

Winter wheat cultivars and breeding lines are screened for resistance to Cephalosporium stripe and eyespot every year at the Palouse Conservation Field Station and Plant Pathology Farms. Currently, Tilt and Topsin-M are the only fungicides registered for eyespot; we are testing potential new fungicides for effective disease control at the Plant Pathology Farm. Once promising candidates are found, testing will move into commercial fields.

Screening for snow mold resistance occurs in grower fields near Mansfield, WA. Potential new varieties with effective resistance have been released (e.g., Bruehl) and potential new varieties and new sources of resistance are being tested. This work is part of our long-term goal to improve resistance of winter wheat varieties to these important diseases and thereby reduce yield losses for Washington State wheat growers.

### Epidemiology and Control of Rusts of Wheat and Barley

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Rusts of wheat and barley were monitored throughout the Pacific Northwest (PNW) using trap plots and through field surveys during the 2008 growing season. Through collaborators in other states, stripe rusts of wheat and barley were monitored throughout the US. In 2008, stripe rust occurred in 18 states, but severities were generally low throughout the country. However, the disease caused yield losses over 20% on susceptible winter and spring wheat cultivars in our experimental plots. Leaf rust was light but stem rust caused damage in some barley fields in the PNW. A total of 33 wheat stripe rust races and 11 barley stripe rust races were identified, of which one new race was identified for each of the wheat and barley stripe rusts. We have developed gene-specific molecular markers and used them to determine genetic relationships of races and compare populations of stripe rust. The first group of linkage maps were constructed for stripe rust genes through sequence comparison with stem rust and screening our stripe rust bacterial artificial chromosomal library. We constructed the first custom gene chip for stripe rust and used it to study genes involved in the different stages of the rust lifecycle. Through cooperation, 28 races were identified from barley stem rust samples collected in 2007 in Washington. In 2008, we evaluated more than 15,000 wheat and 5,000 barley entries for resistance to stripe rust and other diseases. We developed wheat germplasm with high level of high-temperature adult-plant (HTAP) resistance through marker-assisted pyramiding of genes previously identified from 'Alpowa' and 'Express'. We completed studies to determine the genetics and map genes for race-specific all-stage resistance in 'IDO377s', 'Zak', 'PI 181434', and 'PI 480148'; and identified four new genes in these wheat genotypes. We also map a gene for non-race specific HTAP resistance in



the *Yr8* near-isogenic wheat line. To answer the questions why race-specific all-stage resistance is not durable and non-race specific HTAP resistance is durable, we completed experiments to elucidate mechanisms of stripe rust resistance using the microarray technology. In 2008, we made wheat custom gene chips based on genes identified in the previous studies to determine common and unique genes regulated by various genes for either all-stage or HTAP resistance. Molecularly, HTAP resistance is more broadly based than all-stage resistance. Through collaborating with Dr. Dubcovsky's program at UC Davis, we cloned resistance gene *Yr36*. In 2008, we evaluated 18 fungicide treatments including different rates and application combinations of Topguard, BAS 556 01, and Evito for control of stripe rust in experimental fields near Pullman, WA. Better formulations and applications of fungicides were identified.

### *Rhizoctonia* Resistant Wheat -- Potential New Resources for Control for Soilborne Pathogens

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Pacific Northwest (PNW) wheat, barley, legume and canola varieties are susceptible to the broad host-range soilborne pathogens that cause *Rhizoctonia* root rot and *Pythium* root rot. Effective control of these diseases will likely require additional approaches and resources. We have identified promising new sources of genetic resistance against *Rhizoctonia solani* AG-8 and *R. oryzae*, *Pythium ultimum* and *P. irregulare* group I. These four pathogens are among the most damaging to PNW dryland cereal production systems. Until the generation of the *Rhizoctonia*-resistant wheat genotype Scarlet-Rz1 by mutagenesis, non-GMO resistance to root diseases has been elusive. The resistance in Scarlet-Rz1 is readily deployable by wheat breeders, making it unique. In greenhouse trials, Scarlet-Rz1 seedlings are resistant to about ten-fold more pathogen than is detected in symptomatic field soils. Field trials are being planned to determine how seedling resistance impacts field traits, such as heading date and yield. Chromosome 4 from the wild grass *Thinopyrum* confers resistance to eyespot, an important disease of winter wheat caused by the soilborne pathogen *Tapesia yallunde*, when introduced into hexaploid wheat Chinese Spring. We have determined that seedlings of Chinese Spring carrying *Thinopyrum* chromosome 4 also are resistant to *R. solani* AG-8 and *P. ultimum*. Scarlet-Rz1, Chinese Spring-chromosome 4 addition lines and other genotypes of wheat under development offer novel genetic resources for combating *Rhizoctonia* and *Pythium* in the PNW.

### Real-time detection and quantification of *Rhizoctonia* and *Pythium* species on the Cook Agronomy Farm.

K. L. SCHROEDER, T. C. PAULITZ, AND P. A. OKUBARA. USDA-ARS, ROOT DISEASE & BIOLOGICAL CONTROL RESEARCH UNIT, PULLMAN, WA

Populations of *Rhizoctonia* and *Pythium* are diverse in eastern Washington, with multiple species/anastomosis groups present throughout the region and within individual fields. The process of identifying the pathogen present in a sample is laborious and the high diversity increases the difficulty in accurately identifying and quantifying the important species present in a field. Recently, real-time PCR assays were developed for both of these organisms to provide a new tool for more accurate measurements of pathogen populations. With this new tool, the biology and disease management strategies for these organisms can be better evaluated. Evidence from recent surveys for the presence of these pathogens suggests that various environmental and soil factors may influence the species composition and populations of these pathogens. This composition may also be influenced by crop rotation. To further evaluate the impact of crop rotation and spatial distribution of these pathogens, soil samples were collected from the Cook Agronomy Farm near Pullman, WA. This research farm was established in 1999 to test direct-seed cropping systems on a field scale and includes 369 GPS sampling locations spaced every 30 m. A three-year rotation was established to include winter wheat-alternate crop-spring wheat, with each rotation occurring every year. The alternate crops consisted of a winter and/or spring variety of pea, lentil, barley or canola. Soil samples were collected from about 115 sites from the spring wheat portion of the field following the alternate crop. DNA was extracted from each soil sample using a Barocycler™ and Mo-Bio Soil DNA kit, and

quantified with species-specific primers and real-time PCR. *Rhizoctonia solani* AG-2-1 occurred more frequently in fields with a history of canola, with a higher frequency following spring canola (48% of sites) compared to winter canola (28%). *Rhizoctonia oryzae* was detected more often following winter alternate crops (39-44%) than spring crops (24-37%). Of four *Pythium* species examined, *P. irregulare* group IV and *P. rostratifingens* had the highest incidence of occurrence (66% and 67% respectively). These species of *Pythium* were also higher following winter canola and pea versus spring canola and pea. *Pythium ultimum* and *P. irregulare* group I, two of the more virulent species of *Pythium*, were seldom observed on this farm.

## Ten Years of Plant Pathology Research at the Cook Agronomy Farm: What Have We Learned?

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The Cook Agronomy Farm has provided important information for understanding root diseases under direct-seeded conditions in the higher rainfall annual cropping zones of the Palouse, at a landscape scale. This farm has served as an important outdoor laboratory to test disease management techniques such as chemical fallow, residue management and precision N application. The primary *Rhizoctonia* species on the farm is *R. oryzae*, which has an aggregated, patchy distribution and is not influenced by crop rotation. On the other hand, *R. solani* AG 2-1, a brassica pathogen, was strongly influenced by rotation, and was found almost exclusively in the plots that had either spring or winter canola the previous 1 or 2 years. Surprisingly, *R. solani* AG-8, the cause of bare patch, is almost completely absent from the farm, despite 10 years of direct-seeding. Chemical fallow reduced *R. solani* AG-2-1 but not *R. oryzae*, only after 3 years in the absence of a host, although the fallow was not completely weed-free. This indicates that *Rhizoctonia* can survive for long periods in intact roots in chemical fallow, or as microsclerotia, in the case of *R. oryzae*. The predominant *Pythium* species on the farm are *P. irregulare* group IV and *P. rostratifingens*. The most virulent species, *P. ultimum*, is very rare on the farm. Unlike *Rhizoctonia*, *Pythium* is more evenly distributed across the landscape. *P. irregulare* group I is also less prevalent, but highly pathogenic on legumes such as lentils, peas and chickpeas. Fusarium crown rot probably has been the most yield-limiting disease on the Cook Farm, especially since the wheat varieties were hard red, managed with high N levels to attain protein. This disease is exacerbated by drought and excess N fertilizer levels. We have been able to see crown rot every year, especially on dry sites and in low rainfall years. *F. culmorum* is the predominant species, with less *F. pseudograminearum*. Rotation does not have a large effect on these pathogens, which mainly infect grassy hosts. Splitting N application in the fall and spring, as opposed to all in the spring, did not consistently reduce Fusarium crown rot averaged across the entire landscape. Precision application of N, based on landscape position and amount in the soil, also did not consistently reduce disease when averaged over the entire field, but may reduce disease at specific locations. Take-all, caused by *Gaeumannomyces graminis* var. *tritici*, has occurred at very low levels on the Cook Farm. This disease is primarily controlled by rotating with non-host broadleaf crops such as pea or canola every 3<sup>rd</sup> year.

## Screening Wheat and Brassica Germplasm for Resistance to *Rhizoctonia* Root Diseases

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*Rhizoctonia solani* infection can cause poor stands of both wheat and canola and even bare or severely stunted patches when inoculum levels are high. Crop rotation alone will not control the disease because there are different taxonomic groups of the pathogen that can infect multiple crops. For example, *Rhizoctonia solani* AG-2-1 is particularly virulent on canola and *R. solani* AG-8 affects both wheat and canola. The disease is particularly troublesome in direct-seed systems or when the crops are planted into dying weeds or volunteers treated with herbicides. Genetic resistance in various crops would be an efficient means to control the disease. Up to now, no wheat or canola varieties have been identified with good levels of resistance. We examined the levels of resistance in a diverse set of *Brassica* genotypes collected from different breeding programs with both winter and spring growth habit types. A total of eighty five genotypes of *Brassica napus*, *B. rapa*, *B. carinata*, *B. juncea* and *Sinapsis alba* were evaluated in the growth chamber for their resistance to both *R. solani* AG-2-1 and AG-8. The percentage

of seedlings emergence after seven days, survival of seedlings after 21 days, shoot length, root length and disease severity were used as criteria for evaluation. *R. solani* AG-2-1 was highly pathogenic compared to AG-8. None of these genotypes exhibited complete immunity or complete resistance, but significant differences in susceptibility levels were observed. Two hybrids from Germany (Flash and Sitro) and one open pollinated from Dekalb (CWH688), performed significantly better than the others. Approximately 400 synthetic (partially wild) wheat lines were screened by a combination of field and greenhouse screening. Three lines (Syn 381, SPCB 3118 and SPCB 3233) have appeared consistently more tolerant and are being bred with locally adapted varieties.

## Identification and Inheritance of Resistance to Selected Herbicides and *Rhizoctonia* Root Rot in Barley through Induced Mutagenesis

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Mutations create genetic variation in plants, and therefore, provide raw material for natural selection and for human selection via plant breeding. Induced mutagenesis can be used to increase mutation rates and to select for useful agronomic and quality traits such as disease resistance, shorter plant height, larger seeds, higher protein content, etc.

Crop resistance to a given herbicide can be a powerful tool to selectively control problem weeds with efficient chemical use. Or it can be used to avoid plant back restrictions put on certain crops after herbicide use, e.g., imazethapyr, trade name Pursuit®, Beyond® (imazamox), Maverick® (sulfosulfuron). In the case of barley, these herbicides used on previous crops carry barley plant back restrictions. Selection for Pursuit® resistance has been successful in various crops such as wheat, corn and soybeans, but not in barley. Resistance to Pursuit® should give resistance to Beyond®, as well, and possibly Maverick®.

Mutation breeding also can be used to select disease resistance. For example, *Rhizoctonia* root rot causes stunting, reduced vigor and bare patches in field thus limiting yield potential in small grain production. This disease, in particular, is most severe under reduced tillage systems. No resistance to the disease has been reported in barley.

The objectives of this research are to identify resistance in barley to the herbicides mentioned above and to *Rhizoctonia* root rot through greenhouse and field screening and selection. The ongoing research can ultimately release improved barley cultivars that give growers more flexibility in their crop rotations and production.

## Successful Biological Control of the Cereal Leaf Beetle in Washington State

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By 2008 the cereal leaf beetle (*Oulema melanopus*) had spread into 19 counties, primarily in eastern Washington. It has a wide host range in the grass family, and in Washington caused yield losses of 25% in spring wheat. In the absence of any control, cereal leaf beetle (CLB) could cause yield loss in Washington spring wheat worth \$39 million per year. If chemical insecticides were the only control option, they could cost Washington state farmers \$6.75 million annually.

The primary biological control is the wasp, *Tetrastichus julis*, which parasitizes CLB larvae. This tiny wasp is specific to CLB and will not harm humans, animals, or plants. Once stung by *T. julis*, CLB larvae continue to feed on cereal plants until they pupate, when they will die. They will not develop into adults (which also damage crops), nor will they lay eggs.

Farmer cooperators, whose fields had high infestations of CLB, maintained field insectaries where we released the parasitoids. *T. julis* has survived and multiplied across the state extremely successfully. In 2008, parasitism levels of CLB by the wasp exceeded 95% at most dryland sample sites. The wasp is increasing also across the irrigated Columbia Basin.

Farmers should not need to spray to control CLB. Currently labeled insecticides kill both the parasitoids and CLB.

We encourage farmers who find CLB infestations to contact Diana Roberts (509-477-2167) so we can determine the level of parasitism in their fields and help them make viable management decisions. You may find more information at <http://www.spokane-county.wsu.edu/>

The larval parasitoid is distributed successfully across Montana, Utah, Oregon, and Idaho, and is moving on its own into adjacent regions in Canada, following the natural movement of CLB. At this time California has not reported CLB infestations in commercial fields.

## Weather and Predator Populations at Central Ferry 2007-2008

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At Central Ferry Washington, populations of *Hippodamia convergens*, a native ladybird species, is a major predator of aphids and the Cereal Leaf Beetle. *H. convergens* over winters in adjacent mountains at about 4500 feet in edge forest protected habitats.

The beetle must migrate and feed to produce ova and mate. Early spring immigrants feed only as adults on cereal crop insects. *H. convergens* typically arrives in late May and the population increases to 40% of tillers by early July. They are very active in warmer weather above 65 F. The CLB threshold has been demonstrated to be 40% flag leaves infested with at least 40% leaf surface destroyed. No reduction in yield occurs at and below this point, and Tri-State growers have decided to not spray unless the CLB larvae exceed this level prior to boot stage.

In 2008 a record cold spring held predator populations to low levels and it was too cold for efficient searching. Compared to 2007 activity 2008 *H. convergens* were late in arrival and less efficient so that pest populations caused crop damage. Summer CLB Adults grass germ plasm and late seed spring cereals in 2008 at Central Ferry Washington, and required a rescue treatment of Pyrethroid insecticide. All insecticide sprays kill predator and parasitoid populations when used for aphids and CLB.

## Weed Control and Chickpea Yield with Preplant and Preemergence Herbicide Application Timings

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Broadleaf weed control in chickpea is based on preplant or preemergence herbicides. This study was designed determine herbicide efficacy, crop safety, and resulting crop yield of various preemergence herbicides applied before and after planting. This information could be used to better allocate labor, equipment, or management during spring operations.

This experiment was established in April of 2008 to determine how the timing of application for various herbicides affects weed control, crop safety and chickpea yield. Eight herbicide treatments were applied at each of three different timings, 14 or 7 days prior to and 7 days after crop seeding. A nontreated control and a weed-free control were included. Individual plot size was 7 x 35 feet. Sierra chickpeas were planted on May 6, 2008 at approximately 175,000 seed/A. The only soil movement following spring disking was that done by the planting operation and a culti-packing done to the entire experiment area following the 7 days after planting application timing. Weed density and biomass were measured August 20, 2008. The crop was harvested September 29, 2008.

Visual crop injury was not observed in any herbicide treatment. Weed populations were very light and mayweed chamomile (dogfennel) was the predominant species. Other observed species included annual sowthistle and prickly lettuce. Total weed density and biomass differed significantly among treatments as did chickpea yields. Weed density and biomass tended to decrease with later herbicide applications of Sencor, Spartan, Valor, or a combination of these herbicides. Weed density and biomass with Pursuit tended not to be affected by timing. Treatments of Spartan and Valor alone and their tankmix tended to have less biomass than other treatment, particularly at later application timings. Chickpea yields also tended to increase with later herbicide application timings, other than with Pursuit. The top yielding treatment was Valor plus Spartan applied at the latest timing, while the poorest yielding treatment was Sencor plus Pursuit applied at the earliest timing.



## Part 3. Agronomy, Economics, and Sustainability

### Linking a Decade of Geospatial Information and Alternative Land-Use Management to Soil Quality

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The Palouse region of the Pacific Northwest contains some of the most highly erodible soils in the United State. Long-term use of continuous direct seeding, a form of no-till and alternative crop rotations has been shown to improve soil quality leading to increases in soil N and C. This study incorporates soil quality measurements and geospatial information collected annually for 10 yr at geo reference sites across landscape position under direct seed and varying alternative rotation managements at the Cook Agronomy Farm This database will enable growers to quantify improvements in soil quality associated with land-use management and terrain. Twelve-ha field plots were divided into four landscape positions: summits and south slopes with a Bt horizon, summits and south slopes without a Bt horizon, north slopes and bottoms with a Bt horizon and north slopes without a Bt horizon. Soil samples were collected in spring wheat entry points of winter wheat-chickpea-spring wheat and winter wheat-barley-spring wheat rotations. Several biological measures of soil quality were employed to determine the affect of 10 yr of land-use on plant available N. Measurements included: particulate organic matter (POM), the size and turnover rate of organic N pools, nitrification potentials and inorganic N ( $\text{NH}_4^+ + \text{NO}_3^-$ )-N. All soil quality data revealed changes in nitrogen due to rotation and landscape position. Inorganic N measurements were significantly higher in summits and south slopes compared to north slopes and bottom land (41 vs. 28 mg N  $\text{kg}^{-1}$  soil) and in the legume small grain rotation relative to the small grain rotation without legume (42 vs. 27 mg N  $\text{kg}^{-1}$  soil). Nitrification potential, a measure of the microbial population's potential to convert  $\text{NH}_4^+$  to  $\text{NO}_3^-$  and POM-N, a potential measure of seasonal plant available N, were significantly higher in summit south slope\*legume rotations. POM-C revealed increases in carbon on all landscape positions and rotations due to long-term direct seeding. Soil nitrogen pools were significantly higher in the legume rotation of the summit and south slope with a Bt horizon (244 mg N  $\text{kg}^{-1}$  soil) relative to the small grain rotation of the north slope without a Bt horizon (97.1 mg N  $\text{kg}^{-1}$  soil). Larger pools of soil N contributed to significantly higher plant available N ( $\text{NH}_4^+ + \text{NO}_3^-$ )-N values. These results indicate that land-use management, alternative crop rotations and geospatial information can be coupled to measure and improve soil quality.

### Changes in Soil Organic Carbon after 10 Years of No-Till at the Cook Agronomy Farm

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Globally, soils play a critical role in terrestrial carbon (C) storage and dynamics. The soil C pool (2250 to 2500 Gt) is approximately 3 to 4 times the atmospheric (760 Gt) and biotic (560 to 600 Gt) C pools, respectively. Therefore, the soil C pool has the potential to positively or negatively influence atmospheric  $\text{CO}_2$  concentrations and consequently, global climate change. Adoption of conservation tillage and cropping systems that reduce tillage, eliminate fallow, increase cover cropping and biomass inputs by intensifying cropping, increase fertilizer use efficiency, and use of high yielding crop varieties shows great potential for removing  $\text{CO}_2$  from the atmosphere and sequestering it in soils. In the Pacific Northwest, changes in tillage/residue management, cropping intensity, and fertilizer management appear to have the greatest potential for increasing SOC stocks in dryland agricultural soils.

Our goal was to assess changes in soil organic C following 10 years of NT under a 3 year rotation of SW-WW-alternative crop in the surface 30-cm and also to a depth of 5 feet. The 369 georeferenced locations



were sampled in the spring/summer of 2008 for comparison to soil organic C content in the 1998 soil samples. In addition to soil sampling, the surface mulch layer (soil plus residue) was sampled separately to determine the amount of C in this new pool created under NT conditions (i.e., mulch; mulch to 10-; 10- to 20-; and 20- to 30-cm). Five foot soil cores were taken and separated by horizon at 184 of the 369 georeferenced locations. Soil samples continue to be analyzed for soil organic C and are expected to be completed this summer.

Soil C sequestration rates are predicted to peak within 5 to 10 years and approach a new steady-state 20 to 50 years following a change in management or until the soil storage capacity is reached. Quantifying the amount and rate of change after 10 years of NT at the Cook Agronomy Farm will improve our understanding of soil C storage and also aid in developing a regional soil C sequestration protocol for quantifying and verifying changes in SOC content under NT conditions. Furthermore, samples will be archived for future analysis that may include determination of soil organic C pool sizes and turnover.

### Profitable No-Till Rotations for the Cook Agronomy Farm: Economic Results for 2006-08

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Using average yields, crop prices and input prices over the 2006-08 period, a garbanzo/hard red spring wheat (HRSW)/hard red winter wheat (HRWW) rotation outperformed other rotational choices (Tables 1 & 2) for the Cook Agronomy Farm. Returns for other rotations ranged from 22% as profitable in terms of returns over total costs (peas) to 64% as profitable (winter triticale). Garbanzos were only grown in 2008, and since statewide yields were 16% above average, our 2008 yield of 16.75 tons/acre was reduced by 16% as well. Crop prices were based on three-year averages for 2006-2008 (see tables). A full report is available at <http://www.uidaho.edu/~kpainter/#CAF>.

Table 1. Average yield by selected crop, Cook Agronomy Farm, 2006-2008

Crop	Year:			Average
	2006	2007	2008	
Spring Barley (ton)	2.10	1.95	1.74	1.93
Spring Canola, RR (cwt)	20.11	17.96	15.49	17.85
Spring Peas (cwt)	10.87	15.71	17.50	14.69
Spring Garbanzos (cwt) <sup>1</sup>			16.75	14.00
Winter Triticale		1.75	1.90	1.82
Soft White Spring Wheat (bu)	63.84	52.00		57.92
Soft White Winter Wheat (bu)	91.70	76.00	62.10	76.60
Hard Red Spring Wheat (bu)	63.84	52.00	40.00	51.95
Hard Red Winter Wheat (bu)	91.70	76.00	60.00	75.90

<sup>1</sup> 2008 yield for garbanzos of 16.75 cwt was reduced by 16% as 2008 yields statewide were 16% higher than the previous two years.

Table 2. Comparison of 2006-2008 average returns by rotational crop choice (\$/acre/year)

Rotation:	Over Operating Costs:	Over Total Costs:
HRSW/HRWW/Spring Peas	\$124 65%	\$13 22%
HRSW/HRWW/Spring Barley	\$126 66%	\$20 35%
HRSW/HRWW/Spring Canola (RR)	\$138 72%	\$27 47%
HRSW/HRWW/Winter Triticale	\$150 79%	\$37 64%
HRSW/HRWW/Spring Garbanzos	\$191 100%	\$58 100%

Crop prices assumptions: Hard red spring wheat: \$7.96/bu; hard red winter wheat, \$7.88/bu; soft white wheat, \$5.85/bu; garbanzos, \$30.67/cwt; winter triticale, \$153/ton (based on feed corn prices); spring peas, \$13.01/cwt; spring canola, \$14.92/cwt; spring barley, \$136.61/ton

HRSW = hard red spring wheat

HRWW = hard red winter wheat

## Snow Redistribution and Soil Water Storage as Impacted by Surface Residue

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Spatial variation of available soil water has important environmental and economic effects and implications by affecting crop yield and quality and effective fertilization recommendation. Studies show that no-tillage (NT) practices, compared to conventional tillage (CT), result in more soil water storage by retaining more snow in stubble, enhancing infiltration and reducing evaporation. We hypothesized that the residue also affects the spatial variation of soil water. Our objectives were to evaluate residue effects on snow redistribution and the spatial variation of soil water in the Palouse area of the PNW. Two side-by-side farms near Pullman, WA, one under NT, the other under CT, were surveyed for snow depth, snow water equivalent (SWE), and resultant soil water storage during the winter season of 2007-2008. Results indicated that snow pack was distributed more evenly and had less spatial variation under NT. Compared to CT, NT retained 10-20 cm more snow by its standing residue at the ridge top for the events surveyed. Snow water equivalents also showed larger spatial variation in CT. The soil water in the spring was the lowest at the ridge top areas, and highest at valleys in both treatments. However, under CT, soil water at the ridge top area was 6% less than, and in valleys 17% more than, the average over the entire treatment area. Such variation was much smaller in NT where soil water at the ridge top was only 4% less than, and in valleys 6% more than, the treatment average. Although many factors may have contributed to the spatial variation of soil water, residues under NT retarded the generation of runoff, retained more snow at the ridge top and steep-sloped areas, and likely reduced the soil water spatial variation.

## Preserve CRP Soil Quality by Direct Seeding

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As growers approach the end of Conservation Reserve Program (CRP) contracts, they are faced with the decision of how to manage these lands as they return to crop production. Lands returning to production after enrollment in CRP can be managed to maintain the many improvements in soil quality that have occurred over the life of the CRP contract, such as higher organic matter, increased water infiltration and improved soil structure. CRP lands are an excellent place to begin direct seeding and avoid some of the issues normally associated with the transition from conventional tillage to direct seeding. We assessed changes in soil quality with conservation and conventional practices in lands that were eligible to return to production after ten years of enrollment in CRP. When tillage was used, soil quality measurements quickly changed for the worse in the first year! Soil organic matter fractions were quickly degraded and lost to the air as CO<sub>2</sub>. In conventionally-tilled plots, soil organic matter fractions and pH were lower after only one year compared to CRP grassland. In additional studies, we found that with tillage not only did organic matter decline, but nutrient and water contents were lower; soil microbial communities shifted away from those found in CRP; water infiltration decreased; and the amount of soil vulnerable to water and wind erosion increased. We found that the soil quality of direct seed CRP takeout was similar to the original CRP with respect to pH, soil enzymes, the soil microbial community and organic matter fractions than conventionally tilled soils. Direct-seed management maintains soil quality in lands previously enrolled in CRP. Direct seeding of crops into CRP lands will preserve the soil quality benefits accrued during the years in grassland. CRP takeout can be used to assist in a smooth transition to direct seed cropping systems.

## Wheat Grain Yield Trends in Whitman County, Washington

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More wheat is produced in Whitman County than in any other county in the United States. Since 1934, countywide average wheat grain yield has increased from 24 to 76 bu/acre. Before 1960, wheat varieties could not respond to years of high precipitation because their grain yield potential was low and/or the soil was deficient in nitrogen. Grain yields increased with the widespread availability and use of nitrogen fertilizer in the 1950s

followed by the release of high-yield-potential semi-dwarf wheat varieties in the 1960s. By the 1980s and onwards countywide average wheat yields continued to increase despite many years of lower than average precipitation (data not shown). Separate countywide average winter wheat and spring wheat yield data in Whitman County are available beginning in 1972. From 1972 to 2007, winter wheat yield increased by an average of 0.91 bu/acre per year (49 to 81 bu/acre, Fig. 1). Countywide spring wheat grain yield also increased during this time period at an average rate of 0.69 bu/acre per year (30 to 55 bu/acre, Fig. 1). Thus, the grain yield gap between winter wheat and spring wheat in Whitman County has grown from 19 to 26 bu/acre in the last 35 years.

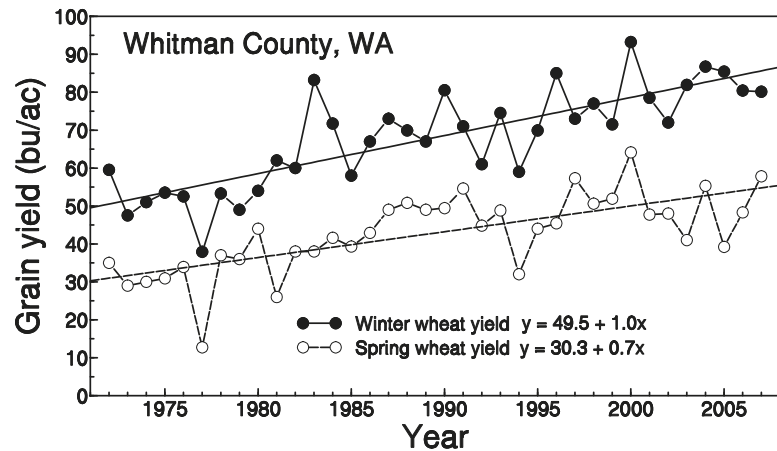


Fig. 1. Countywide winter wheat and spring wheat grain yields in Whitman County, WA from 1972 – 2007. Data show that winter and spring wheat yields have increased by an average of 0.91 and 0.69 bu/acre per year, respectively, over the past 35 years. Data are from USDA-National Agricultural Statistics Service.

## Historic Winter Wheat Yields in Adams County, Washington

W.F. SCHILLINGER AND R.I. PAPENDICK, DEPARTMENT OF CROP AND SOIL SCIENCES, WSU

The first successful wheat crop was harvested in Adams County in 1880. Accurate countywide grain yield data have been available since 1929. In the past 80 years, average countywide wheat yields have increased from 15 bu/acre to about 50 bu/acre, an increase of 0.42 bushel per year (Fig. 1). Essentially all dryland farm acreage in Adams County is in a winter wheat – summer fallow rotation. Better winter wheat varieties, herbicides, fertilizers, tillage management, and so forth continue to drive grain yields upward. Figure 1 clearly shows that, before the introduction of nitrogen fertilizer in the 1950s, wheat did not make productive use of rainfall during wet years. Although the amount of annual precipitation has fluctuated widely from year to year, there are no consistent long-term trends during the past 80 years. However, since 2000, crop-year precipitation has been less than the long-term average in all years except 2006.

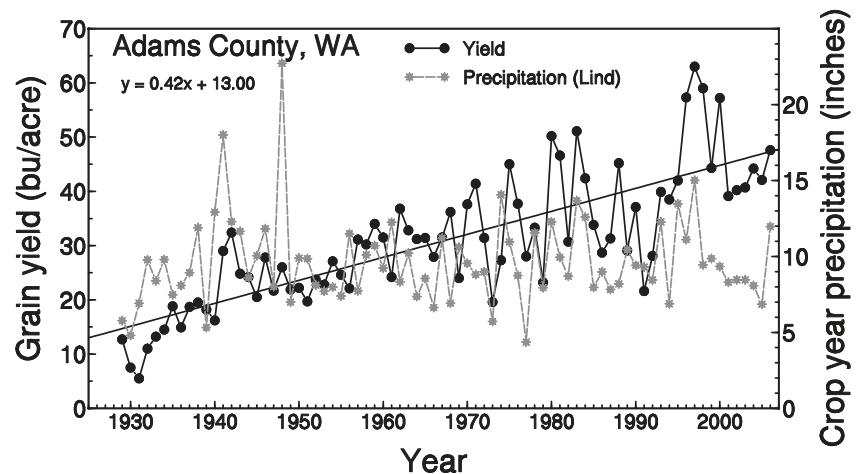


Fig. 1. Long-term average countywide dryland wheat grain yields for Adams County, Washington, superimposed with crop-year precipitation from Lind, WA. Long-term average precipitation at Lind is 9.52 inches. Yield data are from USDA-National Agricultural Statistics Service.



## Chemical Summer Fallow to Reduce Dust Emissions in the Horse Heaven Hills

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Blowing dust from excessively tilled summer-fallowed fields in the Horse Heaven Hills is a major air quality concern in the Tri-cities, Washington. The two major goals for this study are to: (i) determine, based on measured soil moisture in early April, the likelihood of having adequate seed-zone moisture for successful late-August planting into tilled summer fallow and; (ii) provide the research-based information needed for USDA-NRCS to implement farm programs to entice wheat farmers to change from traditional tillage fallow to conservation tillage fallow or chemical fallow in the Horse Heaven Hills. Beginning in March 2006, replicated on-farm experiments were established on the David Pearson and Mike Nichols farms. The Pearson farm is located in the central Horse Heavens on deep Ritzville silt loam soil. Average annual precipitation at the Pearson site averages 8.0 inches. The Nichols farm is located in the western Horse Heavens on deep Warden silt loam soil and annual precipitation averages 6.0 inches. Wheat farmers Pearson and Nichols manage all aspects of field operations for the experiments. The experimental design at both sites is a randomized complete block with four replications. Each plot is 200 ft long and 60 ft wide. Total plot area at each site is 9.5 acres. Tillage treatments are (i) traditional tillage summer fallow, (ii) conservation tillage summer fallow, and (iii) chemical summer fallow. We estimate that seed-zone moisture will be adequate for late August – early September deep-furrow planting only about 50% of the time for the traditional-till and conservation-till treatments and likely never possible for the chemical fallow treatment.

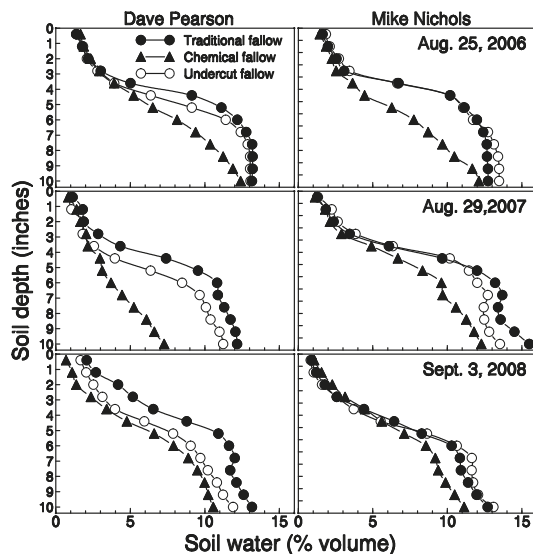


Fig. 1. Seed-zone moisture in late August-early September as affected by three types of summer fallow in 2006, 2007 and 2008 at two farms in the Horse Heaven Hills. The most extensive drying of the seed zone always occurred with chemical summer fallow. At the Pearson farm, the conservation-till retained less seed-zone moisture than traditional-till in two of three years. We suspect that the conservation-till summer fallow was too cloddy in these years and we will adjust the angle of the rotary paddles behind the undercutter implement in 2009 to make smaller soil clods. There have been no differences in seed-zone moisture between conservation-till and traditional-till at the Nichols site.

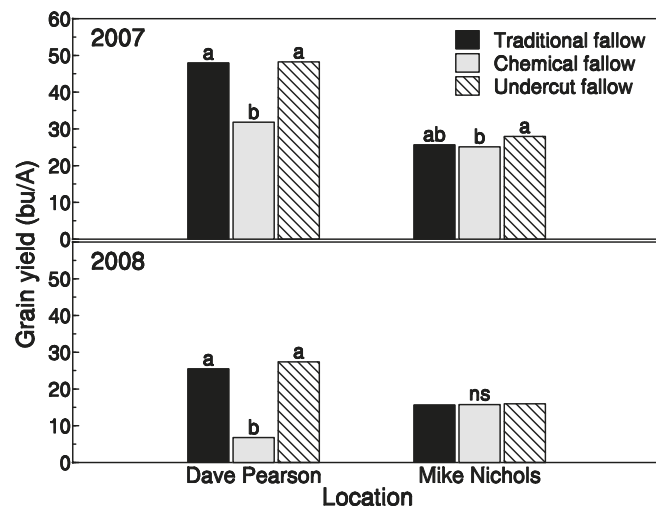


Fig. 2. Grain yield of hard red winter wheat at two farms in Horse Heavens in 2007 and 2008 as affected by method of summer fallow. Early planting was possible during both years at the Pearson site in traditional-till and conservation-till treatments that resulted in significantly higher grain yields compared to late-planted wheat on chemical summer fallow. At the Nichols site, early planting with traditional-till and conservation-till was successful in August 2006 (i.e., 2007 crop year), but late-planted wheat on chemical summer fallow had almost the same grain yield because ample fall rains occurred by October 15. For the 2008 crop year, winter wheat was "dusted in" to all treatments and fall rains did not occur until late November, resulting low grain yields for all treatments.

## Horse Heaven Hills On-farm Undercutter Evaluation

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Winter wheat- summer fallow (WW-SF) is the predominant cropping system in the Horse Heaven Hills area of south-central Washington. Soil loss due to windblown dust is a significant problem in the area due to a lack of sufficient residue and roughness during the summer fallow period. Studies conducted by Schillinger in research plots have shown the use of the undercutter as the primary tillage tool improved the surface roughness and residue cover while maintaining soil moisture.

In 2008, four on-farm research trials were established in the Horse Heaven Hills region of central Washington. Four additional studies will be established in 2009. Two primary tillage treatments (undercutter and disk) were established. The study design was a randomized complete block with 6 blocks per treatment and three observations per block. Data taken was roughness (chain method), percent residue coverage, weight of standing and flattened stubble and wheat stand. Yield will be taken after the crop has matured. Data from the 4 sites will be combined for analysis.



Preliminary data indicate that on-farm use of the undercutter leaves highly significant increases in both standing and flattened stubble on the soil surface in comparison to conventional (disk) primary tillage. Percent residue cover is also higher in the undercutter treatments as compared to the disk treatments. Wheat stands and surface roughness were not different between the two treatments. Yield data will be taken at harvest time in the summer of 2009. If there are no differences in grain yield, our data would indicate that the undercutter is a significant improvement over conventional tillage tools in maintaining both standing and flattened surface residues and thus providing protection from wind caused soil erosion.

## Preliminary Agronomic and Economic Results from WAWG/NRCS Undercutter Project

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The WAWG/NRCS Undercutter Project is targeted to the winter-wheat/summer fallow region of the Oregon and Washington which receives 12 or less inches average annual precipitation. The undercutter method of summer fallow farming employs a wide-blade V-sweep for primary tillage plus fertilizer injection, followed by as few as one non-inversion rodweeding operation. Tillage is reduced from the traditional eight operations to as few as three operations using the undercutter method. The undercutter method increases surface residue and roughness generating more protective cover against wind erosion compared to traditional tillage.

Forty-seven growers located in 10 counties in Washington and Oregon enrolled in the program, which is administered by the Washington Association of Wheat Growers. The authors interview these growers at regular intervals. Participating growers received a 50 percent cost share for purchase of a new undercutter capable of injecting fertilizer at the time of primary tillage. Individual cost-share payments averaged \$15,320, including \$980 for the fertilizer application equipment. Total payment to growers equaled \$720,042. By Fall 2008, 11 of the 47 growers had completed a 2-yr fallow/winter wheat (WW) cycle with the undercutter system. Average WW yields with the two systems were virtually identical for these growers at 42-43 bu/ac. Of the 11 growers, seven estimated their profit would improve, by an average of +8.7% with the undercutter system. The remaining 4 were unsure of profit changes at this early point of the comparison, or estimated equivalent profit with the two systems. The 11 farmers averaged 1.27 rodweedings with the undercutter system versus 1.36 with their conventional fallow system in the dry 2007-2008 production years. Herbicide applications were nearly identical with the two systems. As more farmers complete a complete a full rotational cycle with the undercutter system, we will collect more definitive comparisons.

## Dust Mitigation and Monitoring Research for Williston Reservoir Beaches in British Columbia

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Williston Reservoir in northern British Columbia was created when BC Hydro constructed Bennett Dam on the Peace River in 1968 to generate hydroelectric power. Williston Reservoir is the largest body of freshwater in British Columbia with a surface area of 438,000 acres and a shoreline of 1100 miles. The First Nation Tsay Keh band was forced to relocate to the north end of the reservoir as a result of the water impoundment. Each year the draw down of the Williston Reservoir for the production of hydroelectric power results in the exposure of approximately 25,000 acres of wide flat beaches with surfaces comprised predominantly of fine-grained sediments. On exposure in the spring, these sediments are prone to deflation by wind, resulting in large dust storms. With funding and coordination by BC Hydro, we initiated a 3-year study to determine the effectiveness of roughening the beach with tillage by lifting silt and clay from below the soil surface on dust mitigation by trapping saltating soil particles. The objective was to (i) evaluate the effectiveness of two tillage practices to mitigate dust from beaches, and (ii) conduct regional dust monitoring at six sites surrounding Williston Reservoir. The tillage experiment in 2008 was located on Omineca Beach and covered 185 acres. Treatments were: (i) tillage with twisted-point chisel with shanks spaced 1 m apart, (ii) tillage with a lister plow with lister blades spaced 1.3 m apart, and (iii) a check. Particulate emissions were measured using an array of 360 Big Spring Number Eight (BSNE) samplers and numerous aerosol monitors. Each of the six regional monitoring sites has a wide array of apparatus to monitor PM<sub>2.5</sub>, PM<sub>10</sub>, and total particulates on a 24-hour basis. Data from 2008 indicate that roughening the beach with tillage effectively reduced sand transport during wind events by reducing the near surface wind speed because of the increased surface roughness and by the trapping of sediment in the furrows (Fig. 1). These, and other experiments, are continuing in 2009 and 2010.



Fig. 1. Trapped sediment on the upwind edge of a twisted-point chisel plot. Trapping of sand reduces the abrasive action of the saltating sand that ejects dust into the air stream.

## Agronomics and Economics of No-till Facultative Wheat at Ralston, WA, USA

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Winter wheat/dust-mulch summer fallow (WW/SF) experiences serious wind erosion in the low precipitation zone (<300 mm annual precipitation) of the Pacific Northwest (PNW). One proposed alternative to WW/SF is no-till facultative wheat (FW). Generally, FW's have less cold tolerance, a shorter but distinct period required for vernalization, and start growing and initiate flowering earlier compared with true WW's. This study compares agronomic, economic, and soil moisture components of FW/chemical fallow (FW/ChF), FW/spring wheat (FW/SW), and WW/reduced tillage SF (WW/RSF) rotations near Ralston, Washington. Over the 2003-2006 (harvest years) study period, which averaged about 300 mm annual ppt, spring soil water content (SWC) was greater for ChF compared with RSF at all depths except 0.3-0.6 m. In the fall, difference in SWC between ChF and RSF disappeared at depths below 0.6m, but was less for ChF from the soil surface to 0.6 m. WW/RSF and FW/ChF were more productive, both economically and agronomically, than FW/SW, with WW/RSF being more productive than either FW rotation by a wide margin. The FW/SW rotation produced lower yields that were more susceptible to fluctuations in crop year precipitation, contained more weeds, cost more to produce, and was less profitable than either WW/RSF or FW/ChF. Net income from the FW/ChF rotation was less variable than WW/RSF; however, net returns over total cost were consistently negative for FW/ChF and averaged \$69 rotational ha<sup>-1</sup> less than WW/RSF. Even though FW/ChF yielded and earned less than WW/RSF, the FW/ChF rotation might become

more viable with further research. The yield of FW following ChF was excellent in 2002 in large-scale demonstration plots, in 2003 in the main study where it out-yielded WW, and in 2006 when FW was planted into ChF without sulfentrazone herbicide. The advantages of FW/ChF include (1) spread-out fall planting and summer harvesting operations; (2) opportunities to control problem winter-annual weeds; (3) better competition with summer annual weeds than spring wheat; and (4) a late planting date that does not rely on seed-zone soil water like WW.

[http://www.sciencedirect.com/science?\\_ob=ArticleURL&\\_udi=B6T5T-4RHXT9K-1&\\_user=10&\\_rdoc=1&\\_fmt=&\\_orig=search&\\_sort=d&\\_view=c&\\_acct=C000050221&\\_version=1&\\_urlVersion=0&\\_urlserid=10&md5=8cf64fc4ed861bd6ca7695fd5af09154](http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T5T-4RHXT9K-1&_user=10&_rdoc=1&_fmt=&_orig=search&_sort=d&_view=c&_acct=C000050221&_version=1&_urlVersion=0&_urlserid=10&md5=8cf64fc4ed861bd6ca7695fd5af09154)

## A Plan for Production and Revenue Intensification at a Seattle Urban Farm

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Marra Farm is a medium sized vegetable garden in South Park, Seattle, a low-income area where local stores stock little fresh produce. Student Youth Garden Works operates a portion of Marra Farm to provide employment and training for at-risk youth, generate revenue and to supply fresh produce. Table 1 displays a revenue maximizing plan with reasonable production risk which was developed for Marra Farm.

Projected revenue and yields per square foot of area appear in columns 3 and 5 of Table 1. Three principles underlie the garden plan in Table 1. First, the plan selects the highest revenue crops within plant families. For example, under *Solanaceae*, staked tomatoes which generate \$3.26/sq ft of garden area are selected. In contrast, sprawl tomatoes, eggplant, and peppers; which generate only \$2.17, \$1.35, and \$0.95 (unlisted data), respectively, per same unit area; are excluded. Secondly, the plan utilizes double cropping to grow high revenue crops during shoulder seasons in some years. These shoulder season crops include kale for fall harvest during Year 1 (*Liliaceae*) and radishes for spring harvest in Year 4 (*Cucurbitaceae*). Thirdly, multiple products from the same crop are harvested when possible as with garlic spears preceding harvest of garlic bulbs. Another unlisted multiple crop would be beet tops as greens when beets are thinned prior to harvesting beet tubers. The reported revenues per square foot with the proposed garden design would generate annual revenue of \$43,926. There is a possibility that the garden could be expanded to 37,026 sq ft useable space or 85% of an acre. This larger area would permit 120 beds sized 4-ft x 47-ft with 2-ft paths, generating an annual income of \$94,127. A proposed business and marketing plan for Marra Farm appear in the following abstract.

**Table 1. Projected Yield and Revenue for a 17,180 Sq Ft Garden, Marra Farm, South Park, Seattle, WA**

Family	Crop	No. Plots	No. Sq Ft	Yield/Sq Ft	Unit	Price/Unit	Revenue/Sq Ft	Revenue/Y
<i>Liliaceae</i>	garlic, fall planted	2.3	685	3.0	count	0.75	2.26	1,546
	onions, green	2.3	685	1.5	bunch	1.50	2.26	1,546
	shallots	2.3	685	6.0	count	0.25	1.50	1,031
	kale	7.0	2,058	1.5	pound	2.00	3.01	6,193
<i>Umbelliferae</i>	cilantro	2.3	685	1.1	bunch	2.00	2.26	1,546
	carrots	2.3	685	0.9	pound	2.00	1.81	1,237
	celery	2.3	685	1.5	count	1.10	1.66	1,134
<i>Chenopodioideae</i>	spinach	2.3	685	0.4	pound	3.00	1.13	773
	beets	2.3	685	0.8	pound	1.25	1.03	709
	chard	2.3	685	1.0	plant	0.50	0.50	344
<i>Cucurbitaceae</i>	radishes ( <i>cruciferae</i> )	7.0	2,058	1.5	bunch	1.95	2.93	6,038
	cucumbers, trellised	3.5	1,029	1.1	count	1.00	1.13	1,161
	squash, summer	3.5	1,029	0.5	pound	2.00	0.94	968
<i>Leguminosae</i>	peas, snap and snow	7.0	2,058	0.6	pound	6.00	3.31	6,812
<i>Solanaceae</i>	tomatoes, staked	7.0	2,058	1.0	pound	3.25	3.26	6,709
Greens	salad mix	7.0	2,058	0.5	bag	4.00	2.01	4,129
<i>Cruciferae</i>	broccoli	3.5	1,029	0.4	pound	3.00	1.24	1,277
	cabbage, early	3.5	1,029	0.3	count	2.50	0.75	774
<b>Grand Total</b>		<b>70.0</b>	<b>20,571</b>					<b>\$43,926</b>

Note: Garden area is composed of fifty-six 47-ft x 4-ft plots surrounded by 2-ft paths on all sides. The total sq ft of 20,571 exceeds 17,180 because of double crop some years; 70 plots exceeds 56 plots for the same reason. Yields are based on Washington State University EB 0422. Prices are based on Marra Farm sales records from 2008 and earlier years, when available, and from local supermarkets and investigators' estimates when Marra records were not available. The prices assume produce commands a premium among community supported agriculture (CSA) customers.



## Direct Marketing of Produce by an Urban Farm

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The Seattle Youth Garden Works (SYGW) is a non-profit organization that works to empower homeless and at-risk youth by employing them at Marra Farm, a small farm in South Park, Washington. While their job training focus is intended to help the youth transition into more stable employment, SYGW must also be a good farm production and business manager. The previous abstract described the production plan developed for Marra Farm to increase both production intensity and value. This abstract describes a direct marketing strategy to maximize revenue in support of SYGW's youth activities.

The recommended marketing strategy is to sell shares in a community supported agriculture (CSA) program, which provides weekly deliveries of seasonal produce to members. A CSA has several advantages over other direct marketing strategies (e.g., farmers' markets). First, CSA shares are typically sold at the beginning of the growing season and provide a stable early season income source. Second, subscriptions can be sold to people with a full explanation of SYGW's mission, the challenges they face, and the benefits they provide to Seattle's youth and general citizenry. Farmers' market customers are looking for the best produce at the best price, while CSA customers understand they are purchasing from a farm unique in the training it provides for homeless and at-risk youth. Third, the youth could expand their job skills by participating in gardening activities, sales of CSA shares, coordination of deliveries, and/or creating weekly newsletters.

The estimated revenue to SYGW from a CSA structure is based on data gathered from existing Seattle-area CSA's and is listed in Table 1. Our production plan estimates a maximum of 66 shares delivered from May through November (29 weeks). Using the average CSA share price listed in Table 1, the estimated revenue from a CSA marketing strategy is \$43,908 per year.

**Table 1. Community Supported Agriculture Share Prices in Seattle Area**

	Average	Standard Deviation	Minimum	Maximum	Number of Observations
Season Price	\$665.27	\$150.84	\$475.00	\$990.00	11
Season Duration (weeks)	21	2	20	25	9

Note: Share prices are based on a medium-sized basket, which feeds 2 to 3 people, and weekly delivery

## Part 4. Bioenergy Cropping Systems Research

### Preliminary Straw Characterization of Five Biofuels Crops in the Pacific and Inland Northwest

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Plant residues high in cellulosic fiber compounds offer many benefits as fuel products and value-added by-products. Characterization of complex carbohydrates (hemicellulose, cellulose and lignin) of various crop residues and derivative products is important because their presence can make bioconversion of these products difficult and expensive. In the Pacific and Inland Northwest, researchers are considering the production of crops such as canola (*Brassica napus*), camelina (*Camelina sativa*), and flax (*Linum narbonense*) in addition to weed species like *Arundo donax* for potential oilseed, cellulosic fuels and products. The purpose of this research was to provide a preliminary assessment of the fiber content and carbon to nitrogen ratio (C:N) of five plant species which can assist to determine their usefulness for biofuel production, rotational crops, soil amendments, and other by-products. Crop residues of camelina, flax, canola, wheat, and mid-season *Arundo donax* were collected from irrigated fields in the Columbia Basin and analyzed for fiber using the ANKOM automated system and fiber bags and C:N using a dry combustion method. Estimated average cellulose did not differ significantly for camelina (45.71%), canola (48.41%) and flax (41.59%) but these values were significantly higher than wheat (34.08%) and *Arundo* (32.55%), which did not differ from one another. Similarly, percentage of lignin/cutin in camelina

(14.36%), flax (14.90%) and canola (12.69%) did not differ significantly from one another but were significantly greater than wheat (5.50%) and *Arundo* (6.70%) which did not differ from one another. Carbon to nitrogen ratio for these crops was as follows: camelina (109:1), flax (72:1), canola (117:1), wheat (39:1) and *Arundo* (25:1). Overall fiber trends were similar between camelina, flax and canola, which are in the families, Brassicaceae and Linaceae (flax), but variable from wheat and *Arundo*, which are in the Poaceae family. High cellulose content in camelina, flax and canola suggest that these varieties have good potential as cellulosic feedstocks, but the high lignin content indicates that cellulose would be difficult to extract from these crops. However, plant residues with a high C:N could be ideal for soil amendments and carbon sequestration. Lower contents of complex compounds in wheat and *Arundo* may have resulted from the presence of grain in the wheat sample and immature *Arundo*. A slight indication that management practices or location could impact levels of carbon compounds in plant residues was also noted in preliminary findings. Further research on the nature and properties of specific lignin and cellulose compounds in these crops would be necessary to fully understand their potential uses and hindrances. Understanding the biochemical make up of these products can allow producers and researchers realize the potential uses and overcome difficult production barriers.

## Oilseed Crop Fertility

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A project was established as part of the WA State Biofuels Cropping Systems Program (see [http://css.wsu.edu/biofuels/final\\_report\\_2008/](http://css.wsu.edu/biofuels/final_report_2008/)), to 1) Develop baseline growth and nutrient uptake curves to characterize major oilseed crop nutrient needs; 2) Develop nutrient (primarily nitrogen and sulfur) management recommendations for major oilseed crops that maximize oil yield and quality, 3) Disseminate information on oilseed crop fertility management to growers in extension bulletins, and to the scientific community in peer-reviewed journal articles and 4) Evaluate phosphorus requirements of oilseed crops, and rotational benefits of oilseed alternatives on subsequent crops of wheat.

Winter canola was planted on chemical fallow at Davenport and Pullman in fall 2007. Treatments consisted of a range of nitrogen rates (0 to 160 lb N/acre in 40 lb increments with 15 lb S/acre) applied in treatments replicated four times in a randomized complete block experiment design. Winter canola failed to establish at the Pullman location due to lack of moisture. At Wilke, establishment was acceptable but the stand suffered major damage due to a June 2008 frost and was abandoned. Spring canola was sown on the winter site near Pullman; spring canola and camelina were sown on a new site near Davenport. Camelina failed to establish. Spring canola was grown to maturity and harvested to determine seed yield, oil yield and oil quality (oil yield and quality analysis is pending).

An additional P rate study was conducted north of Kamiak Butte to determine phosphorus requirement for oilseed crops (canola, camelina, and flax) compared to lentil in 2008.

There was a curvilinear response to N rate for spring canola at both locations. At both locations, the slope of the response indicated 4.5 lb seed yield increase with each lb of nitrogen applied. There was an 87 lb/ac (15.5%) seed yield response to sulfur at Davenport but no response at Pullman. Nitrogen application timing did not influence yield. There was no significant effect of P rate. This may be a result of elevated residual phosphorus levels, crop growth limited by water availability, or increased crop phosphorus uptake efficiency for all species.

## Composition of Cereal Crop Residue in Dryland Cropping Systems

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Cereal crops and cultivars vary in their composition, and also in their decomposition and contribution to soil organic matter. Large quantities of cereal crop residue that decompose slowly present an obstacle to the adoption of minimum till or no-till seeding, conversely lower quantities of crop residue that decompose more rapidly may leave the soil vulnerable to erosion by wind and water. Decomposition of cereal crop residues is associated with fiber and nutrient content, and growers have observed differences in decomposition among cultivars; however, little information exists on their residue characteristics. Cultivars of spring barley, spring wheat, and winter

wheat grown at four locations in eastern Washington over two crop years were analyzed for neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), C, and N contents, and this information related to straw hemicellulose, cellulose and lignin content. Acid detergent lignin was highest in spring barley (9.9%), and least in winter wheat (9.2%) and hard white spring wheat (9.5%). Fiber components and nutrient content varied by location, precipitation zone, and cultivar. Residue in the drier year of the study had lower NDF, ADF, ADL, C, and C:N ratio. Foot-rot (*Fusarium* spp.) resistant winter wheat cultivars had higher NDF, ADF, and ADL than susceptible cultivars. The analysis used to determine fiber content of straw is expensive and labor intensive. In 2009 we are developing near-infrared spectroscopy (NIRS) as a rapid, non-destructive, chemical-free method to predict residue fiber and nutrient content. Future research will also include residue tannin analysis to help predict straw decomposition. Fiber and nutrient characteristics of residue from wheat and barley cultivars currently produced in the Pacific Northwest can be used to predict residue decomposition in cropping systems that conserve soil and water, and enhance build-up of soil organic matter.

### From the Genetic Model *Arabidopsis thaliana* to the Oil-seed Crop *Camelina sativa*

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The Neff lab studies how external light signals and internal hormone-regulated pathways control seedling development in the model genetic organism *Arabidopsis thaliana*, a plant in the brassica family. We have recently begun translating some of the genetic knowledge gained from these studies for manipulating seedling and adult growth in the closely related oil-seed crop *Camelina sativa*. To do this we have employed and improved previously published methods for transformation of genetically engineered DNA. Using this technique we have initiated a genetic screen for gene-over-expression and gene-deletion mutations that modulate the elongation of seedlings as they transition from growth in the dark (under the soil) to growth in the light. We have also initiated genetic, physiological and biochemical studies to further characterize a family of DNA binding proteins that regulate plant size. Our initial studies suggest that over-expressing a unique mutation in one of these family members leads to larger seeds and taller, more robust seedlings; both traits that may lead to enhanced stand establishment and yield in dry-land cropping systems. In addition to continuing to study the activity of these and other genes in *Arabidopsis* and *Camelina*, we are also working on identifying similar genes in wheat and barley with the ultimate goal of generating taller seedlings that still maintain semi-dwarf growth as adult plants.

### Camelina Survives Bitter Cold Air Temperatures

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Lind experienced very cold air temperatures and high winds in December 2008. During the 3<sup>rd</sup> week of December, there was a full day of high wind (average wind speed 27 mph with gusts to 38 mph) where the maximum air temperature for the day was 8 degrees F. There was about two inches of snow cover on the soil prior to the windstorm, but afterwards more than 80% of the ground was bare. Then, on the evening of December 16-17, air temperatures dropped to a low of -10 degree F and stayed below 0 degree F for 12 hours.

Following this bitterly cold night with essentially no snow cover, we conducted "grow out" tests of camelina sampled in the field. We initially feared that the cold had killed the camelina, as the cotyledon leaves of plants appeared to be dead. However, after more than a week on the lab bench, camelina sprouted its first true leaves (Fig. 1). Camelina in the field survived the cold. With one year of data from an extremely cold winter event without snow cover, we feel that camelina (at least the Calena variety) may have as much cold tolerance as most winter wheat varieties.



Fig. 1. First true leaves of a camelina plant emerge after more than a week wrapped in a wet towel on a laboratory bench. The plant was collected from a field without snow cover following a night of -10 degree F air temperature. Such preliminary observation indicates that camelina has excellent cold tolerance similar to that of winter wheat.

## Tough Year for Camelina at Lind in 2008

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East-central Washington experienced severe drought during the 2008 crop year (Sept. 1, 2007 – Aug. 31, 2008). The WSU Dryland Research Station at Lind received only 6.77 inches of precipitation in 2008 compared to the long-term average of 9.52 inches. In addition, due to evaporation and sublimation of water from prolonged snow cover, over-winter precipitation storage efficiency in the soil was only 41% compared to the long-term average of 68%. Only 0.30 inches of rainfall occurred during the combined months of April and May. This was one of the toughest crop years in the 93-year history of the Dryland Research Station.

The 2008 crop year was hard for all recrop (i.e., no fallow) crops at Lind. For example, recrop spring wheat yielded only 5 bu/acre. Average grain yield of camelina from a number of experiments at Lind in 2008 was 75 lbs/acre. Although camelina stands averaged 65 plants per square meter when measured in early April, approximately 75% of the established plants died from drought in May and June. Plants that survived were single stem (i.e., no branching) and only 5-8 inches tall.

## Wide Row Spacing Canola Project

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In 2007 Palouse Conservation District contracted with Washington Department of Ecology to develop a project looking at wider row spacing of spring canola. The objectives are to (1) provide possible ways for growers to seed into heavy residue without burning and, (2) help growers learn to grow canola in wide rows economically.

Canola can provide benefits on the farm.

- Breaking a disease cycle in rotation with wheat
- Potential for improving the following wheat crop through weed and disease control
- Provide a tap root to find water and retrieve nitrogen from the previous crop

Three growers in the PCD each graciously provided a 2-acres for the spring canola research plots. They are Lee Druffel, Keith Kopf, and John Leendertsen. Seeding was done by the USDA Agricultural Research Service staff at Pullman with a WSU SeedHawk Drill. The SeedHawk drill was donated by the St. John Grange Supply Agronomy Department manager, Ed Bageant.

In the first year of research, we found no difference in the spring canola yield between seeding at 11 inch seed row spacing and 22 inch seed row spacing.

In April 2009, the plots were again established on the Keith and Heidi Kopf farm east of Pullman. The plots were direct seeded into 100+ bushels per acre winter wheat residue with the Crops and Soils Department Seed Hawk drill. Future implications are that wide rows could reduce seed cost, machine cost, and fuel cost.

## Rotation Benefits of Winter Canola on the Subsequent Wheat Crop

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Multiple-year experiments are being conducted in the low (Ritzville) and intermediate (Davenport) precipitation regions of eastern Washington to document the rotation benefits of winter canola (WC) in wheat-based cropping systems. Our objective is to determine the benefits of winter canola grown in (i) a 4-year WC-SF-WW-SF rotation compared to the traditional 2-year WW-SF rotation in the low-precipitation zone and, (ii) a 3-year WC-SW-SF rotation compared to a WW-SW-SF rotation in the intermediate precipitation zone. Several years of field data from the two locations will be required to “tell the story” on the benefits of WC as a rotation crop. Winter canola



is difficult to establish in tilled summer fallow because emerging seedlings are killed by the hot surface soil when air temperatures are 85° F or greater. Thus, it is necessary to time the planting of WC with the expected air temperature 6-8 days after planting when the WC will be emerging. We have had no problem establishing WC in the intermediate precipitation zone in chemical summer fallow where planting depth is shallow and soil water plentiful. Winter canola tends to use more water in the lower (i.e., 3 to 6 feet) profile than does winter wheat. There was a grain yield reduction of WW at Ritzville in 2008 that was correlated with the high water use by WC grown in 2006 (Fig. 1). These experiments will continue for several years.

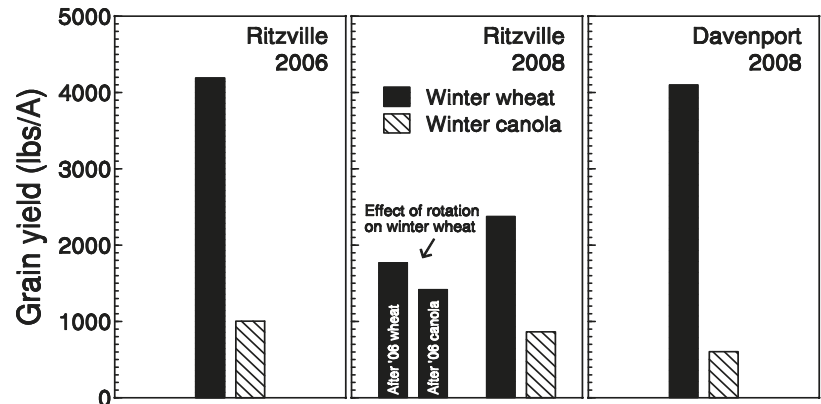


Fig. 1. Winter wheat produced more than four times the grain biomass compared to winter canola during three site years. Monoculture winter wheat after fallow produced 30 bu/a at Ritzville in 2008 compared to 24 bu/a when the previous crop was winter canola (with a year of fallow in between). The wheat grain yield reduction following winter canola is positively correlated with winter canola's greater soil water use in 2006. Abbreviations: SF, summer fallow; SW, spring wheat; WC, winter canola, WW, winter wheat

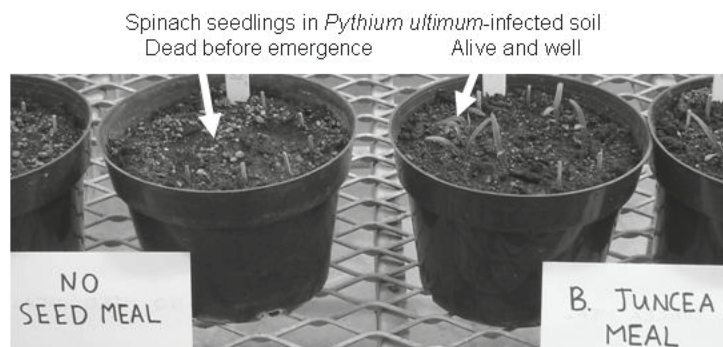
## Brassicaceous Seedmeals as Soil Amendment for Seedling Protection from Soilborne Diseases

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This project has completed a series of greenhouse and laboratory studies on the agricultural value-added uses for Brassicaceous seedmeals (BSM). In some settings BSM may be effective in reducing fungal plant root disease, reducing both pre- and post-emergence seedling damping off, improving emergence and plant growth. In greenhouse trials in soil infested with *Pythium ultimum*, spinach seeds with no BSM treatment had only 35% emergence, and 55% of the emergent seedlings died. *Brassica juncea* (Indian mustard) seedmeal added to the potting mix improved seedling emergence to near 100% and seedling mortality was less than 5%. *Sinapis alba* seedmeal provided marginal reduction in seedling death. Timing of BSM application to soil vs. planting into treated soil was a critical factor in the effectiveness of treatment. Optimal effects generally were seen when seeds were planted 2-4 weeks after BSM treatment.



Economic analysis indicated that among the possible value-added uses of BSM for organic nitrogen fertilizer, weed control, or fungal pathogen control, the latter has the greatest market potential. While other products are available for organic nitrogen and some products and techniques for weed control, the products for fungal disease control are very limited. Given that the price of nitrogen fertilizers continue to rise, BSM-based fertilizers may also become profitable.

These results are from greenhouse experiments of material considered an experimental pesticide. Application of a pesticide to a crop or site that is not on the label is a violation of pesticide law and may subject the applicator to civil penalties up to \$7,500. In addition, such an application may also result in illegal residues that could subject the crop to seizure or embargo action by WSDA and/or the U.S. Food and Drug Administration. It is your responsibility to check the label before using the product to ensure lawful use and obtain all necessary permits in advance.

## Effect of Various Nitrogen and Water Application Rates to Safflower Yield and Oil Concentration

A.N. HANG, DEPT. OF CROP AND SOIL SCIENCES, WSU AND H.P. COLLINS, USDA-ARS VEGETABLE AND FORAGE CROPS RESEARCH LABORATORY, PROSSER, WA

An experiment was conducted using high oleic safflower varieties CW99 OL and S345 on sandy soil at Paterson on April 18, 2008. Seeds were planted on a quarter of a circle at the rate of 25 lbs per acre. P and K were applied preplant at 50 and 75 lbs per acre, respectively. Two irrigation treatments were applied at 70 and 90% evapo-transpiration (ET) using overhead sprinkler. Water application was based on evaporation of the previous day at the same location. Two rates of N were applied at 4 equal portions at 4 stages of plant growth [at seedling stage-2 weeks after planting (WAP); at vegetative stage – 4WAP; at reproductive stage – 6WAP; and at seed fill – 8WAP] for 100 lbs N /a and 25, 40, 40, 40 lbs of N/a at these stages of growth for treatment 2 (150 lbs N/a). At low N and low irrigation, safflower plants set blooms and set seeds earlier than at higher rate. Safflower was mature and ready to be direct combining at 5 months after planting. S345 produced slightly higher seed yield than CW99 OL. Both lines produced higher seed yield and higher oil concentration at low rates of N and water applied. CW99 OL produced an average of 3250 lbs/a with 39.7% oil at 70% ET and 100 lbs N/a compared to 3084 lbs of seed containing 34.3% oil at 90% ET and 150 lbs N/a. S345 yielded 3557 lbs/a containing 40.2% oil at low rates of N and water applications compared to 3017 lbs seed of 37% oil at high rates of N and water applications. Seed moisture was about 6-7%.



## Preliminary Trial of Flax for Seed Production in Washington

A.N. HANG, DEPT. OF CROP AND SOIL SCIENCES, WSU-PROSSER

Flax (*Linum usitatissimum*) is a very old crop with multiple uses. Flax is grown for oil in its seed and fiber in its stem. There are 2 types of flax; seed flax for the oil in its seed and fiber flax for the fiber in its stem. Seed flax is grown to 24 to 36 inches while fiber flax is about 40 inches. Flax seed is crushed for linseed oil and linseed meal. Linseed oil has many industrial uses; linseed meal is used for livestock feed. The fiber in seed flax is used to make fine paper or padding in furniture.

Human consumption of flax seed is increased rapidly for its high dietary fiber, its omega-3 oils and anti-carcinogenic ligands. Flax seed contains high percent of omega-3 fatty acid (50+ %) among oilseed crops grown in Northern America. Whole or crushed seed flax is consumed mostly in bakery products.

Twenty five flax seed lines were grown on Shano silt loam soil at WSU-Othello in 2008. Flax was seeded at the rate of 3 lbs/a in a completely randomized plot with 4 replications. Seedbed containing a residual 77 lbs N/a, 20 ppm P, 345 ppm K, and 17 ppm S and no fertilizer was added. Spartan was sprayed for weed control. Yields varied from 1720 to 2870 lbs/a at 5% seed moisture (25 lines). Three commercial varieties Bethune, Omega and Pembina were planted on sandy soil. Their average yield was 2295 lbs/a. Flax grown on sandy soil did not sacrifice yield lost as canola or safflower but its omega-3 oils was slightly lower than those of the same lines grown on silt loam soil.

### **Spillman Agronomy Farm Endowment Fund**

The Spillman Agronomy Farm is located on 382 acres five miles southeast of Pullman, WA in the midst of the rich Palouse soils. The Spillman Agronomy Farm continues to exemplify the vision of public and private cooperation that has become the 'home' for cereal and pulse crop research and development at Washington State University for over 50 years.

"The importance of Spillman Farm will not diminish as time passes. Multimillion dollar structures on campus will not replace its vital role in crop improvement."

—Bob Allan, retired USDA/ARS Wheat Geneticist

### **Cook Agronomy Farm Endowment Fund**

Located in Whitman County, five miles northeast of Pullman, WA, the 300-acre Cook Agronomy Farm includes soils and topography representative of the annual cropping regions of Washington State. Here, WSU and USDA-ARS research scientists conduct collaborative studies designed to meet the needs of direct-seed cropping systems and precision agriculture.

### **Lind Dryland Research Station Endowment Fund**

The WSU Dryland Research Station was established in 1915 to "promote the betterment of dryland farming" in the 8–12 inch rainfall area of eastern Washington. The Lind station receives the least precipitation of any state or federal facility devoted to dryland research in the United States. Researchers at the Lind Station have released several wheat varieties and conducted numerous scientific studies related to agronomy, diseases, weed ecology, conservation tillage, farm economics, and drought stress physiology.

### **Wilke Research Farm Endowment Fund**

The Wilke Research and Extension Farm is located on the east edge of Davenport, WA in the intermediate rainfall zone (12–17 inches of annual precipitation) of eastern Washington in what has historically been a conventional tillage, 3-year rotation of winter wheat, spring cereal, followed by summer fallow. The 320-acre farm was bequeathed to WSU in 1982 by Beulah W. Wilke for agricultural research and extension. WSU partnered with farmers and the agricultural industry to create a demonstration farm devoted to developing new farming systems based on annual cropping, alternative crop rotations using no till systems that are suitable for the soils and climate of the intermediate rainfall system.

These endowment funds have been established to secure the future of agronomic cropping systems including cereal and pulse crop research and development by your tax deductible charitable gifts.

**Mail to:**

CAHNRS Alumni and Development Office  
PO Box 646228  
Pullman, WA 99164-6228

For additional support or information on estate planning, please contact Caroline Troy. (509) 335-2243, [ctroy@wsu.edu](mailto:ctroy@wsu.edu).



Direct-seeding winter peas at the WSU Cook Agronomy Farm with the new Horsch drill with Anderson openers.

*Photo by David Huggins*