2010
Dryland Field Day Abstracts

HIGHLIGHTS OF RESEARCH PROGRESS

WASHINGTON STATE UNIVERSITY EXTENSION

Department of Crop and Soil Sciences
Technical Report 10-2

WSU Dryland Research Station Field Day—Lind, June 17, 2010

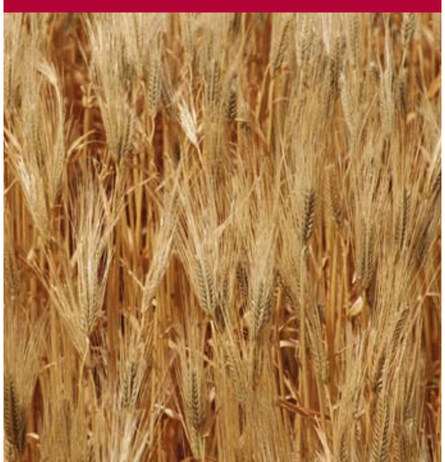
WSU Wilke Farm Field Day—Davenport, June 23, 2010

WSU/USDA–ARS Palouse Conservation Station Farm Field Day—Pullman, June 24, 2010

2010 Dryland Field Day Abstracts: Highlights of Research Progress

Technical Report 10-2

Editors: Debra Marsh, David Huggins



Cover photo: *Mark Sheffels, Wilke farm cooperator, direct seeding a large wireworm study south of Davenport.*

Photo by Aaron Esser.

Welcome to our 2010 Field Days!

As Chair of the Department of Crop and Soil Sciences, I am proud to introduce the ***2010 Dryland Field Day Abstracts: Highlights of Research Progress***. This publication has a simple purpose: to introduce you to numerous research projects conducted in 2010 by WSU faculty and USDA-ARS research scientists working as part of, or in cooperation with, the Department of Crop and Soil Sciences.

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; and 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 2010 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
Dept. of Crop & Soil Sciences

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Cooperative Personnel and Area of Activity

Elson S. Floyd	President, Washington State University
Daniel J. Bernardo	Dean, College of Agricultural, Human, and Natural Resource Sciences
Linda Fox	Associate Dean and Director, CAHNRS/WSU Extension
Ralph P. Cavalieri	Associate Dean and Director, Agricultural Research Center
Richard T. Koenig	Chair, Department of Crop and Soil Sciences

Cereal Breeding, Genetics and Physiology

Wheat Breeding & Genetics

R.E. Allan (Collaborator), USDA ..... 335-1976 ..... allanre@mail.wsu.edu
K.G. Campbell, USDA ..... 335- 0582 ..... kgcamp@wsu.edu
A.H. Carter ..... 335-6198 ..... ahcarter2wsu.edu
K. Gill ..... 335-4666 ..... ksgill@wsu.edu
S.S. Jones ..... 360-416-5210 ..... joness@wsu.edu
K.K. Kidwell ..... 335-7247 ..... kidwell@mail.wsu.edu
M.N. Neff ..... 335-7705 ..... mnneff@wsu.edu
M.O. Pumphrey ..... 335-0509 ..... m.pumphrey@wsu.edu
D.R. See, USDA ..... 335-3632 ..... deven.see@wsu.edu
C. Steber, USDA ..... 335-2887 ..... csteber@wsu.edu
K. Balow, N. Blake, A. Burke, J. Chatelain, V.L. DeMacon, J. Hansen, R. Higginbotham, C. Hoagland, L.M. Little, L. Murphy, W. Nyongesa, G. Poole, L. Reddy, P. Reisenauer, S. Rynearson, M. Santra, G.B. Shelton

Barley Breeding & Genetics

A. Kleinhofs ..... 335-4389 ..... andyk@wsu.edu
S.E. Ullrich ..... 335-4936 ..... ullrich@wsu.edu
D. von Wettstein ..... 335-3635 ..... diter@wsu.edu
C. Boyd, T. Drader, U. Gill, V.A. Jitkov, G. Kannangara, H. Lee, S. Nair, J. Nirmala, P. Reisenauer, M. Wood

Crop Diseases

Cereal Cephalosporium Stripe, Foot Rots, Snow Molds, Wheat Streak Mosaic

T.D. Murray ..... 335-9541 ..... tim_murray@wsu.edu

Root Diseases

P. Okubara, USDA ..... 335-7824 ..... pokubara@wsu.edu
T. Paulitz, USDA ..... 335-7077 ..... paulitz@wsu.edu
D. Weller, USDA ..... 335-6210 ..... wellerd@wsu.edu
K. Schroeder, N. Walters

Rusts, Smuts; Foliar, Virus and Bacterial Diseases

L. Carris ..... 335-3733 ..... carris@wsu.edu
K. Evans ..... 335-8715 ..... kent_evans@wsu.edu
H. Pappu ..... 335-3752 ..... hrp@wsu.edu
T. Peever ..... 335-3754 ..... tpeever@wsu.edu
B. Schroeder ..... 335-5805 ..... bschroeder@wsu.edu
W. Chen, USDA ..... 335-9178 ..... w-chen@wsu.edu
X.M. Chen, USDA ..... 335-8086 ..... xianming@mail.wsu.edu
R.F. Line, USDA ..... 335-3755 ..... rline@wsu.edu
T. Chen, A. Wan, D.A. Wood

Wheat Quality, Variety Evaluation

Wheat Quality

B. Baik ..... 335-8230 ..... bbaik@wsu.edu
B.S. Beecher ..... 335-4062 ..... bbeecher@wsu.edu
C.F. Morris, USDA ..... 335-4062 ..... morrisc@wsu.edu
M.L. Baldridge, A.D. Bettge, P.K. Boyer, J. Clark, D.A. Engle, E.P. Fuerst, T. Harris, G.L. Jacobson, W.J. Kelley, G.E. King, M.J. Lenssen, J. Luna, B. Paszczynska, D. Ramseyer, S. Sykes, S. Vogl, N. Von Sauer, E. Wegner

WSU Extension Uniform Cereal Variety Testing

S.O. Guy ..... 335-5831 ..... sguy@wsu.edu
A. Horton, J. Kuehner, M. Lauver

Breeding and Culture of Legumes

Dry Peas, Lentils, Chickpeas

R. McGee, USDA ..... 335-9521 ..... rebecca.mcgee@ars.usda.gov
F.J. Muehlbauer (Collaborator), USDA ..... 335-7647 ..... muehlbau@wsu.edu
G. Vandemark, USDA ..... 335-7728 ..... george.vandemark@ars.usda.gov
L. Burns, S.L. McGrew, J. Pfaff

DRY BEANS

P. Miklas, USDA .... 509-786-9258 .... pmiklas@pars.ars.usda.gov

Weed Management

I.C. Burke .... 335-2858 .... icburke@wsu.edu
E.P. Fuerst .... 335-7850 .... pfuerst@wsu.edu
R. Boydston, USDA .... 509-786-9267 .... rick.boydston@ars.usda.gov
J.P. Yenish .... 335-2961 .... yenish@wsu.edu
F.L. Young, USDA .... 335-4196 .... youngfl@wsu.edu
L. Bewick, L. McGrew, J. Nelson, R. Rood

Conservation Systems, Fertility Management and Biofuels

D. Brown .... 335-1859 .... david_brown@wsu.edu
A. Esser .... 509-659-3210 .... aarons@wsu.edu
S. Fransen .... 509-786-9266 .... fransen@wsu.edu
S. Hulbert .... 335-3722 .... scot_hulbert@wsu.edu
D. Huggins, USDA .... 335-3379 .... dhuggins@wsu.edu
R.T. Koenig .... 335-2726 .... richk@wsu.edu
D. McCool, USDA .... 335-1347 .... dkmccool@wsu.edu
W.L. Pan .... 335-3611 .... wlpan@wsu.edu
D. Roberts .... 509-477-2167 .... robertsd@wsu.edu
R.D. Roe .... 335-3491 .... rdroe@wsu.edu
W.F. Schillinger .... 509-235-1933 .... schillw@wsu.edu
B. Sharratt, USDA .... 335-2724 .... brenton.sharratt@ars.usda.gov
J. Smith, USDA .... 335-7648 .... jlsmith@wsu.edu
M. Stannard, USDA .... 335-6892 .... stannard@wsu.edu
B. Barry, D. Bikfasy, R. Bolton, S. Higgins, J. Morse, J. Rumph, R. Rupp, S.E. Schofstoll, R. Sloot, T.A. Smith, D. Uberuaga

Soil Microbiology

L. Carpenter-Boggs .... 335-1533 .... lcboggs@wsu.edu
A.M. Fortuna .... 335-3644 .... afortuna@wsu.edu
A.C. Kennedy, USDA .... 335-1554 .... akennedy@wsu.edu
J.C. Hansen, S.. Higgins, T.L. Stubbs

Turfgrass Seed Production

W.J. Johnston .... 335-3620 .... wjohnston@wsu.edu
R.C. Johnson .... 335-3771 .... rcjohnson@wsu.edu
C.T. Golob

Agricultural Economics

K. Painter .... 208-885-6041 .... kpainter@uidaho.edu

WSCIA Foundation Seed Service

R. Whittum .... 335-4365 .... rwhittum@wsu.edu
G. Becker, D. Hilken, D. Kraus, K. Olstadt, J. Robinson, R. Whittum

Field Stations

SPILLMAN & COOK AGRONOMY FARMS

R. Davis, Farm Manager .... 335-3081 .... rdavis@wsu.edu

WSU / USDA-ARS PALOUSE CONSERVATION FIELD STATION

D. Appel, Farm Manager .... 332-2753 .... dpappel@wsu.edu

WILKE FARM

A. Esser, Adams Co. Director .... 509-659-3210 .... aarons@wsu.edu

LIND DRYLAND RESEARCH STATION

B.E. Sauer, Farm Manager .... 509-677-3671 .... sauerbe@wsu.edu

IAREC-PROSSER, OTHELLO

P. Jacoby, Director .... 509-786-9268 .... jacoby@wsu.edu

Acknowledgement of Research Support, 2009-2010

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

Aeschliman, John—Colfax
Anderberg, Al—Fairfield
Appel, Steve—Dusty
Ashburn, Douglas—Genesee/Uniontown
Bauermeister, Dale/Dan—Connell
Beckley, Gregg—Benge
Beechinor, Jason/Tom—Walla Walla
Blume, Kurt—Genesee
Boyd, Pat—Pullman
Braun, Dave—Ritzville
Bruce, Albert/Doug—Farmington
Brunner, Rick—Almira
Burress, Randy—Moses Lake
Camp, Steve—LacCrosse
CBARC—Pendleton, OR
Clausen, Mike—Rosalia
Cornwall, John—Mt. Hope
Covington, Larry—Nespelem
Davis, Ryan—Pullman
DeLong, Sara/Joe—St. John
Dewald, Rob—Ritzville
Dietrich, Dale—Reardan
Dingman, Russ—Hartline
DM Ranch—Othello
Druffel, Norm/Sons—Pullman
Druffel, Ross/Phil—Colton
Durheim, Wes—Spokane
Els, Jim—Harrington
Ely, Brad—Dayton
Evans, Jim—Genesee
Felgenhauer, Karl—Fairfield
Fleming, Chad—Lacrosse
Fleming, Darrin-Lacrosse
Gady, Larry/David—Rockford
Gering, Gordon—Ritzville
Harlow, David—Pullman
Haugerud, Nick—Colfax
Hauser, Gary—Pomeroy
Heilig, Jerry—Moses Lake
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
Klein, Jake—Ritzville
Knodel, Jerry—Lind
Knodel, Josh—Ralston
Koller, Randy/Roger—Pomeroy
Kramer, Mark—Harrington
Krause, Jerry—Creston
Kuch, Ryan—Ritzville
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
Moon,,Jim—Prosser
Moore, Jim—Kahlotus
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, Jerry—Wilbur
Sheffels, Mark—Wilbur
Smith, Glen—Waitsburg
Smith, Steve—Horse Heaven Hils
Snyder, Jerry—Ralston
Spangler, Dennis—Connell
Stubbs, Jerry/Mike—Dusty

Suess, Randy—Colfax
Swannack, Steve—Lamont
Tanneberg, Jason—Mansfield
Tanneberg, Larry—Coulee City
Thompson, Mark—Waterville
Thorn, Eric—Dayton
Tiegs, Brian—Fairfield
Townsend, Ed—Omak
USDA Central Ferry Farm
Walli, Robert—Ritzville
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
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Central Washington Grain Growers
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Columbia Grain Int'l.
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Great Western Malting
Gustafson, Inc.
Harvest States
Horsch Machinen 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.
Micosoft 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.
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.
Tri-State Seeds
USDPLC
Valent Biosciences
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 Grain 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.

William J. Spillman, breeding plots at Pullman, 1900

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.

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 Sate 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 profitablity 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.

Wheat Variety History at WSU

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 & powdry 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 Snoqualimie 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

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
Diva	2010	SWS	In honor of the temperamental creativity in every great scientist Dr. Kidwell has ever known.

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 Variety History at WSU

VARIETY	YEAR RELEASED	MARKET CLASS	BREEDER	BACKGROUND / NAMED AFTER
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) / Unitan
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
Cougbar	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 History at WSU

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 'Merrit' 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.

Essex – Released in 2010 by USDA-ARS, has a small seed size, with yellow interiors and green coats.

Morena – Released in 2010 by USDA-ARS, as replacement for Pardina, intended for export to Spain.

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 tye 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

Washington Extension Variety Trials 2010 – Bringing Variety Performance Information to Growers

STEPHEN GUY, JOHN KUEHNER, MARY. LAUVER, ANDREW HORTON, DEPT. OF CROP AND SOIL SCIENCES, WSU

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 winter wheat; 16 for soft white and hard spring wheat; and 11 for 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 last year and many 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.

Winter Wheat Breeding and Genetics

A. CARTER, G. SHELTON, R. HIGGINBOTHAM, K. BALOW, AND J. HANSEN, DEPT. OF CROP AND SOIL SCIENCES, WSU

Many changes have been present in the WSU winter wheat breeding program over the last year. We are at the start of our first full field season and are excited to evaluate the new changes that we have made to the program. There are three main areas we have added which we feel will enhance the program established by previous breeders. We are continually working to improve the efficiency and effectiveness of our variety development efforts. Some of these include updating the field and lab equipment, using database management systems, and increasing the number of testing locations across Washington. We also have implemented an early-generation end-use quality screening protocol which will help us better identify those lines with better end-use quality potential early in the breeding process. In the laboratory, we are implementing marker-assisted technology to incorporate genes of interest into adapted germplasm. Primarily we are working with stripe rust resistance genes, foot rot resistance genes, and end-use quality genes.

Even with these changes, our main focus continues to be the development of high quality, highly productive wheat cultivars with resistance to the major pests of the PNW for the various production regions of the PNW. We continue to develop lines with stripe rust resistance, excellent emergence capabilities, winter hardiness, snow mold resistance, and foot rot resistance. To these important issues we also have added evaluating germplasm for wireworm resistance and evaluating breeding lines in no-till production systems.

Xerpha, the newest release from the winter wheat program, is growing in commercial production for its first time over a large number of acres. We are excited about the potential for this cultivar and look forward to improving up the desired traits of all commercially grown cultivars. As such, we have several new lines in variety testing this year. We have eight soft white, six hard red, and two hard white lines under evaluation. About half are in their second year of testing and the other half are new this year. We are eager to watch them this growing season and identify those with variety release potential.

Improving Spring Wheat Varieties for the Pacific Northwest

GARY SHELTON, KIM KIDWELL, VIC DEMACON, WYCLIFFE NYONGESA, SHERI RYNEARSON, AND MIKE PUMPHREY, DEPT. OF CROP AND SOIL SCIENCES, WSU

A total of 26.3 million bushels of spring wheat were harvested in Washington in 2009 from ~585,000 acres, with a statewide yield average of 45 bu/ac (http://www.nass.usda.gov/). Hard red (HRS) and soft white (SWS) spring wheat shared those acres evenly with ~49% of the acres planted to each market class. Hard white (HWS) and soft club (club) spring wheat each accounted for ~1% of planted acres. The Washington State University (WSU) spring wheat breeding program continues to focus on improving production options, profitability and sustainability of spring wheat production. WSU varieties 'Louise', 'Alpowa', and 'Wakanz' accounted for over 80% of the SWS acres planted in the state in 2009. WSU varieties 'Hollis', 'Tara 2002', and 'Scarlet' accounted for approximately 25% of HRS acres planted in 2009. 'Eden' spring club occupied 100% of the reported spring club acres.

WSU experimental lines and newly released varieties topped the WSU Extension Uniform Cereal Variety Testing Program performance trials in 2009:

Babe (formerly WA8039) is a SWS wheat that was released 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 was in the top overall yield group in the high and intermediate rainfall zones in 2009. Babe has the highest three-year yield average of any variety in >20" rainfall zone locations and is second only to Louise for three-year average yield in 16"-20" precipitation locations.

JD (formerly WA8047) is a spring club variety that was released 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 and out-performed Eden in all rainfall zones in 2009.

Diva (formerly WA8090) is a new SWS wheat approved for release in 2010. Diva has excellent grain yield potential across a broad range of production environments; 2) high test weight; 3) outstanding end-use quality; 4) HF resistance; and 5) excellent levels of HTAP resistance to stripe rust. Diva may be an excellent option in the low rainfall zone where the low test weight of Louise can be a concern. Diva was in the top yield group in the low rainfall zone in 2009 and has a higher two-year yield average across low rainfall locations than any other variety.

USDA-ARS Wheat Breeding

KIM GARLAND CAMPBELL[1], ROBERT ALLAN[1], ADRIENNE BURKE[2], CHRIS HOAGLAND[1], LESLEY MURPHY[1], JULIA PIASKOWSKI[2], GRANT POOLE[2], ALLISON THOMPSON[2], CARL WALKER[2]
[1] USDA-ARS, WHEAT GENETICS, QUALITY, PHYSIOLOGY AND DISEASE RESEARCH UNIT, PULLMAN, WA
[2] DEPT. OF CROP AND SOIL SCIENCE, WASHINGTON STATE UNIVERSITY, PULLMAN, WA

The goals of the USDA program are to develop high qualitly club and soft white cultivars and to incorporate new germplasm for disease resistance into soft and hard PNW-adapted breeding lines. The club wheat, ARS970075-3C, and SWW wheat, ARS960277L were approved by the WSU Cereal Variety Release Committee for preliminary seed increase in 2009. 1500 heads of ARS970075-3C were snapped from plots at Pullman and are being increased for breeder seed at Othello in conjunction with the Washington State Crop Improvement. 1500 heads of ARS960277L were also snapped but are being increased at Pullman in a nursery that has been inoculated with strawbreaker foot rot in order to reselect for straw strength. Three additional club wheats plus one additional SWW were entered into the Washington State Extension trials. After more than 5 years of combined testing in replicated nurseries in the USDA program in WA, ID and OR, these new entries were all significantly better than check cultivars Chukar, and Cara for grain yield and test weight with intermediate maturities. One club wheat, ARS970184-1C has had grain yields significantly better than Tubbs and equal to Xerpha in our trials in WA and OR. In 2010, the USDA program combined with the WSU Winter Wheat program to plant replicated yield trials together at Kahlotus, Ritzville, Harrington, Farmington and Dayton. This was expansion of locations throughout the state will result in better predictions for specific environmental adaptation. In 2010, coleoptile length data was recorded for 164 new entries into the USDA preliminary yield trials. These same entries were also assessed for cold tolerance. Marker assisted selection was conducted on over 2000 entries from head rows for resistance to foot rot, barley yellow dwarf virus, preharvest sprouting, and stripe rust. New germplasm from international nurseries was incorporated into spring and winter wheat crossing blocks for resistance to Fusarium crown rot, lesion and cyst nematodes. Those populations were planted in the field in fall 2009 and survived the winter.

End-Use Quality Assessment of WSU Wheat Breeding Lines, and Improvement of Sponge Cake Baking Test

BYUNG-KEE BAIK[1], TRACY J. HARRIS[1] AND HYUN-WOOK CHOI[2], [1]DEPT. OF CROP AND SOIL SCIENCES; [2]SCHOOL OF FOOD SCIENCE, WSU

We facilitate quality evaluation of early and late generation wheat breeder lines for the purpose of developing wheat varieties possessing desirable end-use quality characteristics. For the crop harvested in 2008, approximately 1784 varieties/lines were tested by the WSUWQP in conjunction with the Western Wheat Quality Lab. The test results were analyzed, summarized and reported to the WSU wheat breeders, and would be used for making selections from their breeding lines for the next generation. Spring and winter wheat breeding lines harvested in

2009 are currently undergoing end-use quality testing. Since its inception in 2000, the WSUWQP has contributed to the release of 13 new varieties in all market classes grown in Washington.

The sponge cake (SC) baking test provides a reliable estimation of overall end-use quality of soft white wheat for Asian markets, and is widely accepted as a standard quality test. The SC baking test is, however, lengthy and laborious, and requires substantial experience to conduct with accuracy and reliability, which make it unsuitable for the routine evaluation of a large number of wheat breeding lines. We are in the process of simplifying the SC baking procedure in the egg whipping step; improving its consistency by replacement of cake batter hand mixing with mechanical wire whip mixing; and modifying it for baking a cake of 50 g flour instead of 100 g flour. Egg foam whipping, mechanical batter mixing and 50 g flour cake baking conditions are optimized by comparing egg foam density and sponge cake volume to those of the original procedure. Comparable egg foam density and sponge cake volume to the original procedure were obtained with modifications including extension of egg whipping time without heat input using a KitchenAid mixer, and one time water addition at 3 min before the completion of egg whipping.

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

ADRIENNE BURKE, CHRIS HOAGLAND, CARL WALKER, DAN SKINNER, KIM GARLAND CAMPBELL, USDA-ARS, WHEAT GENETICS, QUALITY, PHYSIOLOGY AND DISEASE RESEARCH UNIT, PULLMAN, WA

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 -13C for winter wheat and -8C 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 seven 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 Drought Tolerance through Integrated Breeding, Physiology and Molecular Genetics in Pacific Northwest Wheat

S. L. SHRESTHA, S. H. HULBERT, K.A. GARLAND-CAMPBELL, AND C. M. STEBER, DEPT. OF CROP AND SOIL SCIENCE, WSU

Drought associated with inadequate precipitation is one of the main limitations of wheat production in the Pacific Northwest (PNW), the main wheat-producing area in the far-western United States. Breeding for drought tolerance is a challenge for breeders in the PNW and many parts of the world because of erratic rainfall and other stresses that affect yield. To address this issue, we have started an integrated breeding, physiology and molecular genetics approach for improving drought tolerance in wheat. We are creating breeding materials through crosses with international drought tolerant (CIMMYT and Australian) or mutant lines and screening for yield under drought conditions through selection from head-rows planted on annually-cropped land at Lind. The varieties in the spring uniform wheat variety trial were screened in 2009 for water use efficiency using carbon isotope discrimination (CID) as an indirect physiological screening method. Plants from the Spillman variety trial were sampled during the flag leaf stage, dried at 70°C, powdered using liquid N_2 and processed for carbon isotope discrimination. The CID values from the genotypes were then correlated with yield from other variety trials in the PNW receiving <30 to >50cm of annual precipitation. The CID was negatively correlated with yield in the low precipitation zone (<30cm of precipitation), where higher CID value was associated with lower biomass accumulation. This indicates CID could be used to select for drought tolerant spring wheat lines. We are also trying to develop marker assisted selection (MAS) as a breeding tool for drought tolerance by mapping drought tolerance traits. Recombinant inbred lines (RILs) from a Louise/Penawawa cross were used to map quantitative trait loci (QTL) in 2009. We found a test weight QTL carried by Penawawa that appears to be associated with photoperiod insensitivity. This indicates photoperiod insensitivity is likely a good trait for drought resistant spring wheat. Overall, we expect our studies will improve the performance of PNW breeding materials for drought tolerance and assist in wheat variety improvement through development of tools such as CID and MAS.

Phenotypes for Drought Tolerance: Can Greenhouse Measurements Mimic the Field?

L. R. Murphy, K. Garland Campbell, and C. Steber, USDA- ARS Wheat Genetics, Quality, Physiology and Disease Research Unit. Pullman WA.

Drought is a major factor influencing yield in crop plants. To date, many phenotypes have been looked at as predictors of drought resistance in wheat, but few have been found that can be measured in the greenhouse, as opposed to only the field, limiting a breeder's ability to make selections to the summer months only. In this study, we compared two physiological phenotypes in two wheat varieties in two field locations and under two greenhouse watering regimes. The measurements were carbon isotope discrimination (CID) and relative water content (RWC). CID values and their correspondence between field and greenhouse fluctuated based on life stage; however, the dry treatment in the greenhouse was not statistically different at 180 DD>Z6.5 and at harvest from our "dry" field site for either genotype. For RWC, there was no difference across locations at jointing, but at 180 DD>Z6.5 both greenhouse watering regimes showed higher RWC in both genotypes compared to the field. It is obvious that the greenhouse watering regimes chosen are not within the real-life water availability in our two field sites. Water stress is already an issue at jointing at Lind and our wet treatment in the greenhouse doesn't reflect the water stress being felt at Spillman by 180 DD>Z6.5. Adjustments to the greenhouse watering regime may remedy this problem, but for every field site and genotype this would most likely need to be altered.

Developing Two-gene Clearfield Wheat Varieties through Marker-Assisted Background Selection

N. Kumar, P. Reisenauer, S.R. Maqbool, B.-K. Baik, C. Morris, A. Carter, J. Yenish, and K.S. Gill, Dept. of Crop and Soil Sciences, WSU

Grass weeds especially jointed goatgrass are a serious concern in the Pacific Northwest cropping systems and may result significant yield loss. The imidazolinone class of herbicides effectively controls most types of grassy weeds affecting various classes of PNW wheat but cannot be used because of the presence of the ALS gene. Mutants for the gene (*ahasl-1d, ahasl-1b and ahas1-1a*) have been developed, and exploited in wheat to achieve effective and economical weed control. Wheat varieties developed through Clearfield technology have become popular due to their ability to control troublesome weeds and benefits for crop rotation with legume crops. Most of the available Clearfield varieties carry single-gene Clearfield technology. These single-gene Clearfield varieties show significant damage at labeled applications rates of the imazamox herbicide which range from 0.031 lb/acre to 0.047 lb/acre; although due to residuals and other factors the wheat crop may get exposed to more than a 0.062 lb/acre rate. Therefore, availability of two-gene Clearfield varieties will reduce that damage caused by the herbicide, therefore resulting in higher grain yield.

Marker-assisted background selection (MABS) is a good approach to transfer useful genes into popular varieties in a targeted and precise manner. Using this approach, we have transferred two-gene Clearfield technology into the backgrounds of the winter wheat cultivars Eltan, Madsen and Rod. We first screen large backcross populations (5000 to 8000 plants) phenotypically for the resistance by spraying with imazamox at the 0.125 lb/acre or 4 times higher than the normal use rate. Resistant plants were subjected to DNA markers analysis first using target gene markers (foreground selection) and then recover the background of the recipient parent genome in a precise way using whole genome SSR markers (background selection). In addition to this, we tested single plants for the yield and the end-use quality parameters. In early generation selection, we apply single kernel characterization system (SKCS) and solvent retention capacity (SRC) test for testing the grain quality from single plant seed. After repeating this cycle in BC_2 generation, the selected plants were tested using full mill and bake test and advanced for the field evaluation. This year, our nine lines are in the WSU variety testing program involving three at all locations and the remaining six at single location (Moses Lake). All the above lines are also being evaluated in advanced field trials. Now this approach is being used to transfer two-gene Clearfield technology along with quality characteristics into the popular variety Xerpha. Furthermore, we are in the preliminary stages of transferring the two-gene resistance into the spring cultivar Louise and the club variety Chukar.

Breeding Wheat for Association with Mycorrhizal Fungi

JULIA PIASKOWSKI[1], KIM GARLAND CAMPBELL[2], CHRIS HOAGLAND[2], JOHN RUMPH[1] AND JOHN KUEHNER[1]
[1]DEPT. OF CROP & SOIL SCIENCES, WSU, PULLMAN, WA
[2]USDA-ARS, WHEAT GENETICS, QUALITY, PHYSIOLOGY AND DISEASE RESEARCH UNIT, PULLMAN, WA

Worldwide, phosphorus resources are anticipated to run out in 50 years. Wheat yields can be limited by available phosphorus on marginal soils that have low organic matter or have undergone severe erosion. Arbuscular mycorrhizal fungi are well established to assist in phosphorus uptake by accessing 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, test weight, and uptake of soil nutrients due to mycorrhizal associations.

Field trials are being conducted in five locations in Eastern Washington over two years to test the responsiveness of five spring wheat cultivars (Alpowa, Blanca Grande, Louise, Otis, and Walworth) to a commercial mycorrhizal inoculant consisting of four fungal species (Micronized Endo®, Mycorrhizal Applications Inc, Grants Pass, OR). The sites from the first year (2009) are all located in low rainfall zones, representing organic (Benge), conventional (Lind) and no-till management (Bickleton). The sites from the second year (2010) include the same management practices, although the no-till and conventional sites, located in Colfax and Pullman, respectively, have higher rainfall. The 2009 data indicate that mycorrhizal colonization of the roots was highest in the no-till site. Mycorrhizal colonization was found to affect yield, 1000 kernel weight, and phosphorus uptake. These results indicate that this mycorrhizal inoculant can exert cultivar-dependent effects, both positive and parasitic, on spring wheat grown in 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.

Uncoupling Coleoptile Length and Adult Stature in Wheat via the *AHL* Gene Family

MICHAEL M. NEFF, DAVID FAVERO, PUSHPA KOIRALA, HAO PENG, JIWEN QIU, KULBIR SINGH, REUBEN TAYENGWA AND JIANFEI ZHAO: DEPT. OF CROP AND SOIL SCIENCES, MOLECULAR PLANT SCIENCES GRADUATE PROGRAM, WSU

In low rainfall, dryland-cropping areas stand establishment can have a major impact on yields of winter wheat. The problem is especially prevalent in areas where winter wheat is generally planted in the last part of August or early in September. During dry years these seeds need to be planted in deep furrows (up to 8") so that the developing seedling has access to ground water. To facilitate stand establishment, wheat breeders have been trying to develop varieties with long coleoptiles as seedlings while maintaining a high-yielding semi-dwarf stature as adults. Unfortunately, few mechanisms have been identified that uncouple the semi-dwarf phenotype of adult plants with reduced elongation of the coleoptile in seedlings. The Neff lab has identified a group of plant-specific genes (*AHL*) that, when mutated in a particular way, uncouple seedling elongation from adult size. The goal of this project is to enhance winter wheat seedling emergence when planted deeply in low-rainfall dryland cropping regions (generally less than 10"/year). This can be achieved by developing varieties that have long coleoptiles as seedlings while maintaining semi-dwarf growth characteristics as adults. Based on our studies in *Arabidopsis* and the oil seed crop *Camelina sativa*, we hypothesize that the expression of specific dominant-negative alleles in the *AHL* gene family, either via a transgenic or TILLING approach, will lead to seedlings with longer coleoptiles without affecting adult stature.

We are now identifying and beginning to characterize AHL genes in wheat to facilitate breeding naturally occurring as well as mutagenesis-induced alleles into high yielding varieties that otherwise have short coleoptiles. This proposal has three main objectives. The **first objective** of this project involves cloning and expression studies of these genes in wheat. Previously identified family members in rice, Sorghum and the model monocot Brachypodium are being used a reference for a polymerase chain reaction (PCR)-based cloning of paralogous genes in wheat. These genes are relatively small with open reading frames of 1 to 1.5 kb. Based on the rice, Sorghum and Brachypodium genomes it is anticipated that there will be between 15 and 30 family members. The three homeologous genomes (A, B, and D) in hexaploid wheat have similar genetic organization, which can complicate gene cloning. Three relative species Triticum monocuccum (a diploid, A genome donor of hexapliod wheat), Triticum (Aegilops) tauschii (a diploid, D genome donor of hexaploid wheat), and durum wheat (tetraploid wheat, having A and B genomes) will also be used for PCR-based cloning. The **second objective** of this project involves using RT-PCR and northern blot analysis to identify those family members that are expressed at high levels in the coleoptile of wheat. The **third objective** will be to alter the expression as well as generate dominant-negative alleles of these coleoptile-specific AHL family members to examine their role in coleoptile elongation.

The Western Wheat Quality Laboratory

Craig F. Morris, Director, Brian Beecher, USDA-ARS Western Wheat Quality Lab, 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 readily available on our web site.

Our current research projects include grain hardness, puroindolines, waxy wheat, soft durum wheat, polyphenol oxidase (PPO), arabinoxylans, SDS sedimentation test, and wheat ash. Our recent publications include studies on physical mapping and a new variant of *Puroindoline b-2* genes in wheat, and the discovery of a new puroindoline b gene in wheat. Two studies on the variation in polar lipids located on the surface of wheat starch, and the variation in polar lipid composition within near-isogenic wheat lines containing different puroindoline haplotypes were recently published in the Journal of Cereal Science. Other research includes the effect of the grain protein content locus *Gpc-B1* on bread and pasta quality, the molecular characterization of the *Puroindoline a-D1b* allele and development of an STS marker in wheat (*Triticum aestivum* L.), the association of *puroindoline b-2* variants with grain traits, yield components and flag leaf size in bread wheat *(Triticum aestivum* L.*)* varieties of Yellow and Huai Valley of China, and scanning electron and atomic force microscopy, and Raman and x-ray photoelectron spectroscopy characterization of near-isogenic soft and hard wheat kernels and corresponding flours. Currently the lab is working on grant-funded research aimed at better understanding the fate of fiber and phytonutrients in whole wheat products during processing. 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.

Barley Improvement for Washington and the PNW

S.E. Ullrich, V.A. Jitkov, M. Wood, H. Lee, and S.G. Nair
Collaborators: A. Kleinhofs, 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 analyze barley genetic traits 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 2009 from the Extension State Uniform Nursery (ExSUN), both Bob and Radiant (>100 loc.-yr) have yielded statistically equal or greater than Baronesse at individual locations. In the 2009 ExSUN across the 11 test locations, eight of 12 WSU advanced hulled lines statistically equaled or beat the yield of Baronesse, the leading cultivar in Washington. Four lines stood out. One line (04WA-113.22) yielded 104% of Baronesse across 27 loc-yr (2006-2009). Other lines that outperformed Baronesse in the 2009 ExSUN (data are for 17 loc-yr, 20007-2009) include 05WA-316K (104% of Baronesse), 05WA- 316.99 (104%), and 05WA-329.49 (101%). 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. Several promising putative mutants resistant to Pursuit® and Beyond® have been identified and are in verification and genetic studies, and have been entered into the variety development program. Such mutants may lead to elimination of the plant back restriction on barley production following winter wheat.

Characteristics and Significance of Grain Hardness of Barley for Food

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

Barely, a rich source of dietary fiber which has been proven to be effective in lowering cholesterol and glycemic index, is an ideal candidate for grain-based functional foods. The objectives of our research were to determine variation in grain hardness among U.S. barley germplasm, factors influencing barley grain hardness and the significance of barley grain hardness in food processing. Barley lines, provided by ten major U.S. barley breeding programs, exhibited a broad range of single kernel characterization system hardness index (SKCS HI) values ranging from 30.1 to 91.9. Vitreousness, evaluated visually using a light box, showed a clear distinction between hard and soft kernels. Hard kernels appeared translucent, while soft kernels appeared opaque on the light box. L*, determined as an indicator of kernel vitreousness using a Minolta chromameter, showed a significant negative correlation ($r = -0.83$, $P<0.01$) with SKCS hardness. Protein, β-glucan and amylose content did not show any significant association with hardness. Under light microscopy, SKCS hard barley lines showed significantly thicker cell walls than SKCS soft barley lines. Both hard and soft barley lines showed similar patterns of cell size and distribution under the scanning electron microscopy. However, hard and soft barley lines showed variation in the degree of starch-protein association and continuity of protein matrix. Hard barley lines with a continuous protein matrix exhibited greater starch-protein adhesion than the soft barley lines, suggesting that starch-protein binding may be one of the major factors influencing barley grain hardness. Association gene mapping of diverse barley lines showed significant polymorphic markers on chromosomes 1H, 2H, 3H, 4H and 7H, suggesting complex quantitative genetic control of barley grain hardness. Pearling loss of barley kernels after 325 sec abrasion showed significant negative correlation ($r = -0.87$, $P<0.01$) with hardness. Proportion of barley flour particles greater than 106 µm ($r = 0.93$, $P<0.01$) and starch damage of barley flour ($r = 0.93$, $P<0.01$) showed significant positive correlations with hardness. These results suggest that barley grain hardness has significant influence on food processing.

Mutation Breeding for Resistance to Selected Herbicides in Barley

H. LEE, S. ULLRICH, I. BURKE, J. YENISH, T. PAULITZ, AND C. COYNE, DEPT. OF CROP & SOIL SCIENCES AND USDA-ARS, WSU, PULLMAN, WA.

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 plant height, nutritional content and resistance to diseases and chemicals. Crop resistance to a given herbicide can be a powerful tool to selectively control weeds with efficient chemical use. In some crops, for example, wheat, corn, soybean and canola, resistance to imidazolinone herbicides, trade names Beyond® and Pursuit®, has been selected through mutation breeding and now commercially utilized. However, this production system imposes plant back restrictions on some crop species due to herbicide carryover limiting options for rotational crops with possible economic loss. Plant back intervals for Beyond® vary depending on different crops ranging from 3 months up to 26 months. In the case of barley, a common rotational crop following winter wheat, 9 to18 months intervals are required. Thus barely resistant to imidazolinone herbicide will provide greater flexibility as a rotational crop. The objective of this research, therefore, is to identify resistance in barley via mutagenesis and selection. The ongoing project has screened mutated seed and selected over 40 putative mutants resistant to Pursuit®. The next step is to verify resistance to Pursuit® and Beyond® and to study the resistance mechanisms and genetics. Preliminary verification studies with several putative mutants indicate that the resistance is real. Ultimately, it is expect to release new improved barley cultivars that give more options for rotational crops.

Kentucky Bluegrass Germplasm for Non-burn Seed Production

W.J. JOHNSTON[1], R.C. JOHNSON[2], K.L. DODSON[1], C.T. GOLOB[1], AND G. K. STAHNKE[1]
[1]DEPT. OF CROP AND SOIL SCIENCES AND [2]WESTERN REGIONAL PLANT INTRODUCTION STATION, WSU

This long-term study consists of 10 Kentucky bluegrass (*Poa pratensis* L.) entries; eight are USDA/ARS Plant Introduction (PI) accessions and two are commercial cultivars ('Kenblue' and 'Midnight'). The selected PI accessions in previous research had expressed high seed yield without burning of post-harvest residue and good turfgrass quality. Several agronomic yield parameters were then evaluated over a 2-yr period and individual plants were reselected within each accession, or check, with the highest seed weight, highest seeds panicle^{-1}, highest panicles area^{-1}, and highest seed yield. Remnant seed of the original USDA/ARS population were also included. Turfgrass plots were established in 2006 and seed production plots (irrigated and non-irrigated) in 2007 at Pullman, WA. The turfgrass trial was evaluated monthly (2007 to 2009) according to NTEP (National Turfgrass Evaluation Program) protocol to determine turfgrass quality. In 2008 and 2009, seed production plots were harvested and seed yield was determined (2009 data presented).

Results for 2009 indicated that selection for seed yield components had a variable response and Kentucky bluegrass seed yield appeared to be dependent primarily on accession. Accession PI 368241 showed the best promise of being able to provide good turfgrass quality and seed yield under non-burn management in both non-irrigated and irrigated seed production. One selection within Kenblue, seed head^{-1}, had good turfgrass quality and seed yield under non-irrigated production. These studies will be followed during 2010 and for several additional harvests to determine if a non-burn Kentucky bluegrass can be developed for sustainable grass seed production in Washington.

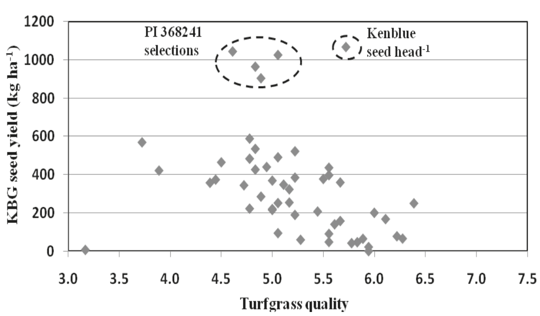

Figure 1. Kentucky bluegrass non-irrigated seed yield vs. turfgrass quality (rated 1-9; 9 = excellent quality) at Pullman, WA, 2009. Conversion: 0.9 x kg/ha = lb/A.

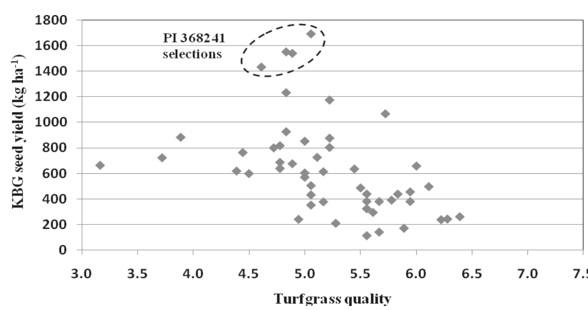

Figure 2. Kentucky bluegrass irrigated seed yield vs. turfgrass quality (rated 1-9; 9 = excellent quality) at Pullman, WA, 2009. Conversion: 0.9 x kg/ha = lb/A.

Part 2. Pathology and Entomology

Optimum Timing for Spring Herbicide Application to Control Rhizoctonia Root Rot in Barley

E. M. Babiker[1], S. Hulbert[1], K. L. Schroeder[2] and T. C. Paulitz[2].
[1]Dept. of Plant Pathology, Washington State University, Pullman WA 99164-6430
[2]USDA-ARS, Washington State University, Pullman WA 99164-6430

Rhizoctonia root rot, caused by *Rhizoctonia solani* AG-8 and *R. oryzae,* is considered one of the main challenges for growers to adopt reduced tillage systems in the Pacific Northwest. In order to determine the effect of time interval period between glyphosate (Roundup) applications and planting date on severity of this disease of barley, experiments were conducted in 2007, 2008 and 2009 in a field naturally infested with a high level of both *R. solani* and *R. oryzae* at the ARS Palouse Conservation Farm. Volunteer plants and grassy weeds were allowed to grow over the winter and plots were sprayed out with Roundup at 2, 7, 14, 28 and 42 days prior to planting with barley. Significant increases in plant height, length of the first true leaf, and number of healthy seminal roots were associated with decreases in disease rating and number of infected seminal roots, as the spray interval increased. Plots sprayed out 2 days or 1 week before planting showed an increase in activity of *R. solani*. The sprayout time required to reach 80% and 90% of the maximum benefits of reduced disease pressure were determined to be 11 to 27 days and 13 to 37 days, respectively. These times are the minimum sprayout intervals required to reduce disease severity and increase seedling health in the following crop.

Combatting *Rhizoctonia* and *Pythium* in Dryland Wheat Production Sites -- Diagnostics and Potential Sources of Resistance

Patricia Okubara[1], Nathalie Walter[1], Timothy Paulitz[1], Kurtis Schroeder[1], Stephen Jones[2], Kimberlee Kidwell[2], Victor DeMacon[2], and Camille Steber[3]
[1]USDA-ARS, Root Disease and Biological Control Research Unit; [2]Dept. of Crop and Soil Sciences, WSU; [3]USDA-ARS, Wheat Genetics, Quality, Physiology and Disease Research Unit

Pacific Northwest (PNW) wheat, barley, legume and canola are susceptible to the broad host-range soilborne pathogens *Rhizoctonia* and *Pythium*, which cause root rot and bare patch. As a first step to better disease control, we used rapid, sensitive and specific molecular diagnostic assays to identify and monitor the species most likely to cause root rot and bare patch in different precipitation zones, and under different tillage and rotation regimens. For instance, *R. solani* AG-2-1 persists in soils grown to wheat without causing much damage, but flourishes when canola or pea is introduced into the rotation. In contrast, *P. irregulare* group I is favored by lentil. Another approach for controlling soilborne pathogens is genetic resistance. Genetic resistance to *Rhizoctonia* and *Pythium* has been elusive for wheat until recently. We are currently working with six novel sources of genetic resistance against *Rhizoctonia solani* AG-8, *R. oryzae*, *Pythium ultimum* and/or *P. irregulare* I. These pathogens are among the most damaging in PNW dryland cereal production systems. In greenhouse trials, seedlings of wheat genotype Scarlet-Rz1 grew well in up to ten-fold more *R. solani* AG-8 or *R. oryzae* group III than cause symptoms in the field. Likewise, seedlings of Chinese Spring carrying Chromosome 4 from species of *Thinopyrum* are resistant to *R. solani* AG-8 and *P. ultimum*. Novel resistance to *R. solani* AG-8 has been generated in wheat cultivars Louise, Hollis and Macon. These genotypes, under selection and advancement, hold promise for enhancing the sustainability of wheat and barley production in the PNW.

Control of Rusts of Wheat and Barley

X.M. Chen, D.A. Wood, M.N. Wang, A.M. Wan, Y.M. Liu, D. Sharma-Poudyal, P. Cheng, and K.C. Evans, USDA-ARS Wheat Genetics, Quality, Physiology, and Disease Research Unit and Dept. of Plant Pathology, WSU

In 2009, stripe rust was accurately forecasted using our newly developed models, and rust updates and advises were provided on time to growers during the crop season, which reduced stripe rust damage and unnecessary use of fungicides. We identified 27 races of wheat stripe rust and 6 races of barley stripe rust and determined their frequencies and distributions in the US; and also 9 stem rust races through collaboration with the Cereal Disease Laboratory in Minnesota. Our studies on population structures, evolutionary mechanisms, and genome and functional genomics of stripe rust using molecular markers, gene sequencing, and comparative genomics approaches have led to a better understanding of the pathogen. In 2009, we evaluated more than 15,000 wheat and 5,000 barley entries for resistance to stripe rust and other diseases. As results of our testing, 13 wheat varieties with adequate stripe rust resistance were released or registered in 2009. Growing resistant varieties in the major wheat fields prevented the potentially more than 15% yield losses in the Pacific Northwest and other regions. In 2009, we officially named three new genes for stripe rust resistance. These genes will be useful in monitoring virulence changes in the stripe rust population, as well as in breeding programs. We also have preliminarily identified at least 20 different genes, which will allow us to more efficiently identify and map new genes for effective resistance to be used in breeding programs. The results of our fungicide tests are essential for registration of new fungicides. The most of the 15 fungicide treatments tested in 2009 provided control of stripe rust and increased yields. We also tested currently grown cultivars for response to fungicide application to develop integrated control strategies. The integrated control program combining resistant cultivars and effective fungicides reduces input cost and ensures sustainable wheat production.

Natural Suppression of Rhizoctonia Bare Patch with Long-Term No-Till

W.F. SCHILLINGER, T.C. PAULITZ, R. JIRAVA, T.A. SMITH, AND S.E. SCHOFSTOLL, DEPT. OF CROP AND SOIL SCIENCES, WSU, AND USDA-ARS

Rhizoctonia bare patch caused by *Rhizoctonia solani* AG-8 is a major fungal root disease in no-till cropping systems. In a 13-year experiment comparing various dryland no-till cropping systems near Ritzville, WA, Rhizoctonia first appeared in year 3 in all no-till plots and reached peak levels by year 8 (Fig. 1). Rhizoctonia infected all crops grown with long-term no-till, including winter wheat, spring wheat, spring barley, yellow mustard, and safflower. The area of bare patches was measured in mid-June every year in all plots with a backpack-mounted GPS unit. The area of bare patches began to decline in year 9 and reached near zero levels by year 12 and 13 (Fig. 1). This is the first documentation of natural suppression of Rhizoctonia bare patch in long-term no-till cropping systems in the United States. This field experiment is an extremely valuable living laboratory that will be continued for the foreseeable future.

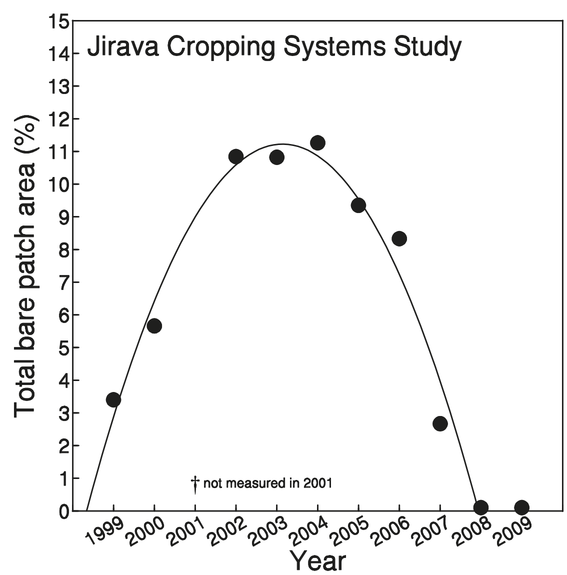

Fig. 1. Total bare patch area in no-till crops grown in a long-term dryland cropping systems experiment on the Ron Jirava farm near Ritzville, WA. Data are the average from all no-till plots including winter wheat, spring wheat, spring barley, yellow mustard, and safflower.

Eyespot, Cephalosporium Stripe, and Snow Mold Diseases of Winter Wheat

TIM MURRAY, HENRY WETZEL III, KATHY ESVELT-KLOS, HONGYAN SHENG, JULIE EVANS, AND MEGAN ROBINSON, DEPT. OF PLANT PATHOLOGY, WSU

Eyespot (strawbreaker foot rot) and Cephalosporium stripe are important diseases of winter wheat in the Pacific Northwest. These diseases have potential to cause 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. Adapted varieties with highly effective resistance to Cephalosporium are not available because resistance genes are not known in the bread wheat gene pool. However, we have transferred resistance from wheatgrass into wheat in collaboration with Dr. Steve Jones, and some of these lines are now being used as parents in breeding programs. Winter wheat cultivars and advanced breeding lines are tested for resistance to Cephalosporium stripe and eyespot every year at the Palouse Conservation Field Station and Plant Pathology Farms (results from 2009 were published in the May 2010 issue of Wheat Life). Currently, Tilt and Topsin-M are the only fungicides registered for eyespot; however, we have identified two new fungicides and are testing them in commercial fields near Prescott and Oakesdale, WA to determine their effectiveness in controlling eyespot. The snow molds occur in the north-central wheat-producing area of eastern Washington, where snow cover can persist for up to 150 days and cause complete yield loss in years when they are severe. Disease resistant varieties like Bruehl and Eltan, and early seeding are the best control methods for the snow molds. Development of new varieties and testing of new sources of resistance is ongoing in field plots near Mansfield and Waterville, WA, and in the growth chambers of the Wheat Plant Growth Facility in Pullman. All of 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.

Wheat Head Armyworm Research Project

DIANA ROBERTS (WSU EXTENSION AGRONOMIST, SPOKANE/LINCOLN COUNTY), KEITH PIKE (WSU ENTOMOLOGIST, PROSSER), PETER LANDOLT (USDA-ARS ENTOMOLOGIST, WAPATO)

In 2007 and 2008, an insect pest, allegedly the wheat head armyworm (WHA) [*Faronta diffusa* (Walker) (Lepidoptera: Noctuidae)], infested winter and spring cereal grains in the Reardan-Davenport area of Lincoln County. Yield loss both years was 35% in WSU spring wheat and barley trials, and 10,000 acres were treated with insecticide to control the pest in 2008. Using Washington Grain Commission funds, a research project was initiated to determine the regional distribution of the pest; its biology, damage, and control.

In 2009 we established 28 trap sites throughout the wheat growing region of eastern Washington, inclusive of Adams, Columbia, Douglas, Franklin, Garfield, Grant, Lincoln, Spokane, Walla Walla, Whitman, and Yakima counties. There were 2 traps per county and 10 in the Reardan-Davenport region. At each site, a trap with a pheromone lure (which attracts the male WHA) was set up, as well as a trap with a feeding attractant lure. These traps were maintained from the third week of May until mid September.

Small numbers of *F. diffusa* males were captured in sex attractant traps at several of the sites with a total of 17 captured for the season. In addition, male *Faronta terrapictalis* Buckett (1969) moths were found in far higher numbers in most of the traps. *F. terrapictalis* is a noctuid moth that is native and widely distributed in temperate western North America. It has no recognized pest status, but is similar to, and may be confused with, the wheat head armyworm moth. The host range of *F. terrapictalis* is unknown. Two other Noctuid moths with possible pest status on grasses were also found.

However, in 2009 no larvae of either *Faronta diffusa* (WHA) or *F. terrapictalis* were found at any of the trap sites, nor in any fields scouted in the Reardan-Davenport area by Ag Link Inc. employees.

It is possible that the damage to wheat in eastern Washington previously attributed to the wheat head armyworm may have been due in part to *F. terrapictalis,* which is referred to locally as the “false wheat head armyworm”. Since no *Faronta* larvae were found in fields, none were reared to adults to confirm species identity, population composition, and which of the *Faronta* spp. is the preeminent damaging species in wheat. .

In the 2010 season we will repeat the insect trapping procedures, but will limit them to the area where most moths were found in 2009. If we find no *Faronta spp.,* we will terminate the project in August 2010.

Controlling Wireworms with Neonicotinoid Insecticides in Wheat

ESSER,* A.D.[1], DEWALD, R.[2], SHEFFELS M.[2]
[1] EXTENSION AGRONOMIST, WSU EXTENSION, LINCOLN-ADAMS AREA, RITZVILLE, WA
[2] WHEAT PRODUCER, LINCOLN COUNTY, DAVENPORT, WA

Wireworm (*Limonius* spp.) populations and crop damage have been increasing in both spring and winter wheat (*Triticum aestivum* L.) production across eastern Washington.

After nearly 30 years of use, the pesticide Lindane was withdrawn by the Environmental Protection Agency. Today nearly all spring cereal crop acres throughout eastern Washington are treated for wireworm control with neonicotinoid insecticides such as Cruiser® (thiamethoxam) and Gaucho® (imidacloprid) at rates between 0.190-0.315 oz/cwt. A majority of winter wheat acres are also being treated with these insecticides at similar rates. At these rates, the neonicotinoids are toxic to wireworms but at sub-lethal doses, or in other words they repel or provide some seedling protection only. Two on-farm tests (OFT) were initiated in the spring of 2008 to examine wireworm control with higher than recommended neonicotinoid insecticide applications to find a lethal dose that will reduce wireworm populations and improve yield and economic return over costs. Both OFT's are a RCBD with 4 replications and 10 and 15 acres in size. At Dewald's farm Gaucho at 2.0 oz/cwt had a trend for improved yield, economic return over costs, and reduced wireworm populations and additional research is needed. At Sheffels' farm Cruiser applied at 0.50 and 1.00 oz/cwt has significantly improved yield and economic return over costs compared to applying 0.00 and 0.25 oz/cwt, but has not reduced wireworm populations.

Part 3. Agronomy, Economics, and Sustainability

New Map of Inland Pacific Northwest Dryland and Irrigated Cropping Areas

W.F. SCHILLINGER AND R.A. RUPP, DEPT. OF CROP AND SOIL SCIENCES, WSU

We created a new map to show the dryland and irrigated cropping areas of the Inland Pacific Northwest (Fig. 1). The dryland cropping zone is divided into three precipitation regions: (i) low – less than 12 inches annual, (ii) intermediate – 12 to 18 inches annual, and (iii) high – 18 to 24 inches annual. We divided the irrigated cropping zone into four segments depending on whether the source of water was from: (i) the Yakima River Basin Project, (ii) the Columbia Basin Project, (iii) pumped from deep wells, or (iv) other sources, such as pumped directly from the Columbia River or its tributaries.

The Yakima Basin is one of the most intensively irrigated areas in the US. The Yakima River Basin Project was initiated in 1905 and delivers water to 509,000 acres of cropland along 174 miles on both sides of the Yakima River. The Columbia Basin Project began in 1951 following construction of the Grand Coulee Dam on the Columbia River and provides water for 650,000 acres of crops. About 148,000 acres is irrigated from deep wells. Most of these wells were drilled in the 1960s with the intention they would be needed only for 10 or 15 years until the

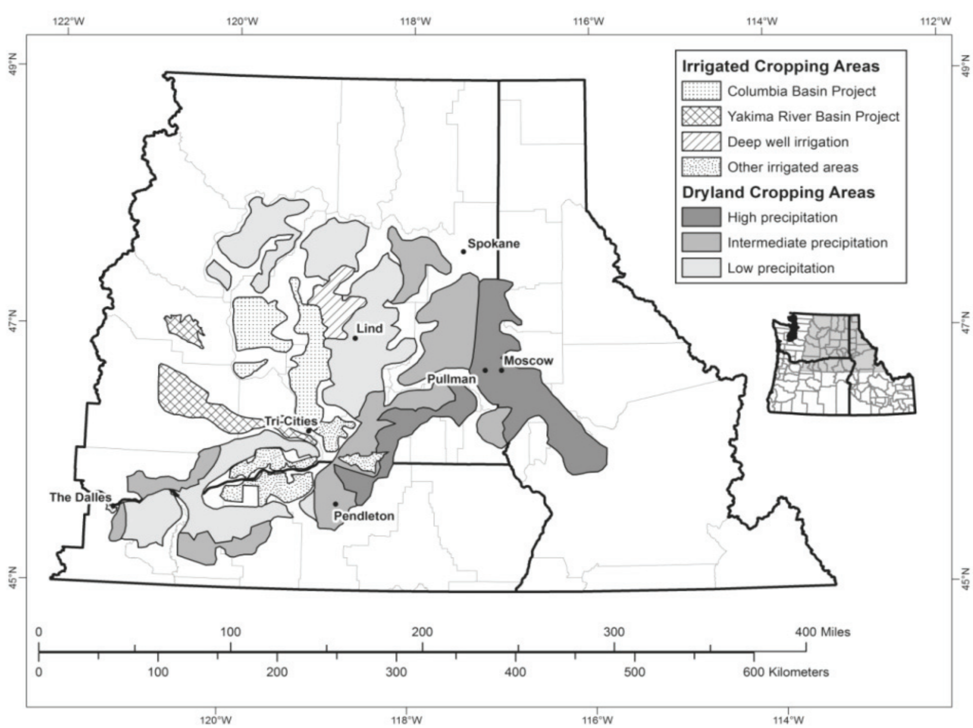

Fig. 1. Map of dryland and irrigated cropping areas in the Inland Pacific Northwest.

second half of the Columbia Basin Project was completed. Now, 50 years later, farmers still irrigate from deep wells, and the status of the second phase of the Columbia Basin Project remains uncertain.

Long-Term Comparison of Winter Wheat–Summer Fallow vs. Continuous Annual No-Till Spring Wheat

W.F. SCHILLINGER, R. JIRAVA, D.L. YOUNG, T.A. SMITH, S.E. SCHOFSTOLL, A.C. KENNEDY, AND T.C. PAULITZ, WSU, WASHINGTON ASSOCIATION OF WHEAT GROWERS, AND USDA-ARS

Grain yields of winter wheat grown after tilled summer fallow (WW-SF) were compared to those of continuous annual no-till spring wheat (NTSW) near Ritzville, WA during the past 13 years. Annual crop-year precipitation during the study period was 10.2 inches compared to the long-term annual average of 11.4 inches. Grain yields of WW-SF were relatively stable and averaged 50.7 bu/acre over the 13 years compared to 28.6 bu/acre for continuous annual NTSW (Fig. 1). Profitability of cropping systems fluctuates widely due to many factors such as cost of diesel, herbicides, and other inputs. However, as a general rule of thumb, recrop spring wheat needs to yield 65% of that of WW-SF to be equally profitable. Using this measure, NTSW was equally as profitable as WW-SF in 5 of 13 years at Ritzville (Fig. 1). A model has been developed to help farmers decide when it may be desirable to plant spring cereals (in lieu of summer fallow) based on measured over-winter soil water storage and expected spring rainfall.

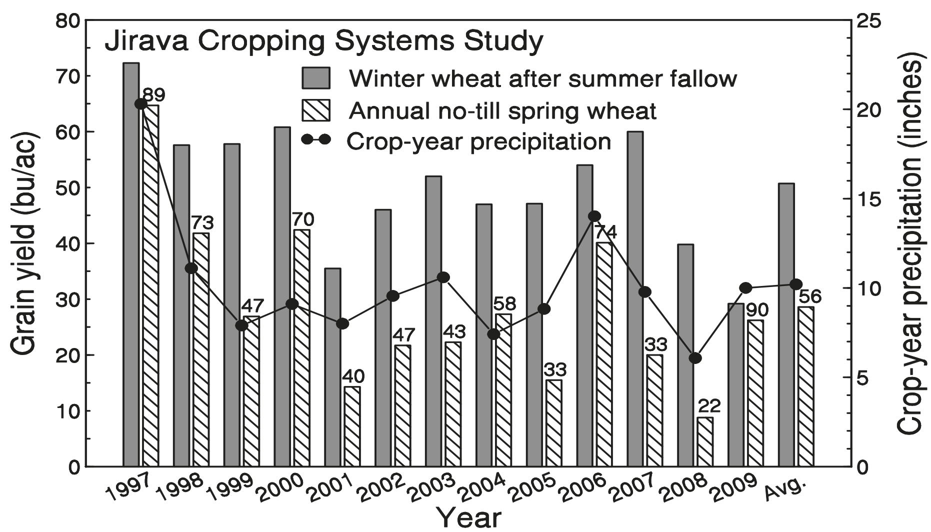

Fig. 1. Grain yield of soft white winter wheat after summer fallow (WW-SF) versus continuous annual no-till soft white spring wheat (NTSW) near Ritzville, WA. Numbers above the NTSW bars indicate the percentage of NTSW grain yield that was achieved compared to the grain yield in the WW-SF system.

Rotation Benefits of Spring Barley on Subsequent Wheat Grain Yield

W.F. SCHILLINGER, R. JIRAVA, T.C. PAULITZ, A.C. KENNEDY, D.L. YOUNG, T.A. SMITH, AND S.E. SCHOFSTOLL , WSU, WASHINGTON ASSOCIATION OF WHEAT GROWERS, AND USDA-ARS

We have conducted a large-scale (20 acre) dryland cropping systems experiment at the Ron Jirava farm near Ritzville, WA since 1997. Crop rotation treatments evaluated over the years include a 2-year soft white spring wheat (SW) – spring barley (SB) rotation versus continuous annual SW. The SW and SB varieties used are Alpowa and Baronesse, respectively. These crops have always been planted no-till during the 13 years of this experiment. Long-term average annual precipitation at the site is 11.4 inches, but only an annual average of 10.2 inches has occurred since the inception of the study. There has been high year-to-year variability in grain yields for both SW and SB.

One consistent pattern has occurred. Spring wheat grain yields following SB are generally greater than monoculture SW (Fig. 1). This SW grain yield boost following SB is not significantly different every year, but there are statistical differences when averaged over the 13 years (Fig. 1). The 13-year average grain yield of SW after SB is 30.4 bu/acre compared to 28.6 bu/acre for monoculture SW. We have intensively measured soil water dynamics in this experiment and can say with certainty that the SW yield differences are not due to water. More likely, the yield increase is due to less Rhizoctonia bare patch disease pressure when SB is included in the rotation (see accompanying article on suppression of Rhizoctonia bare patch).

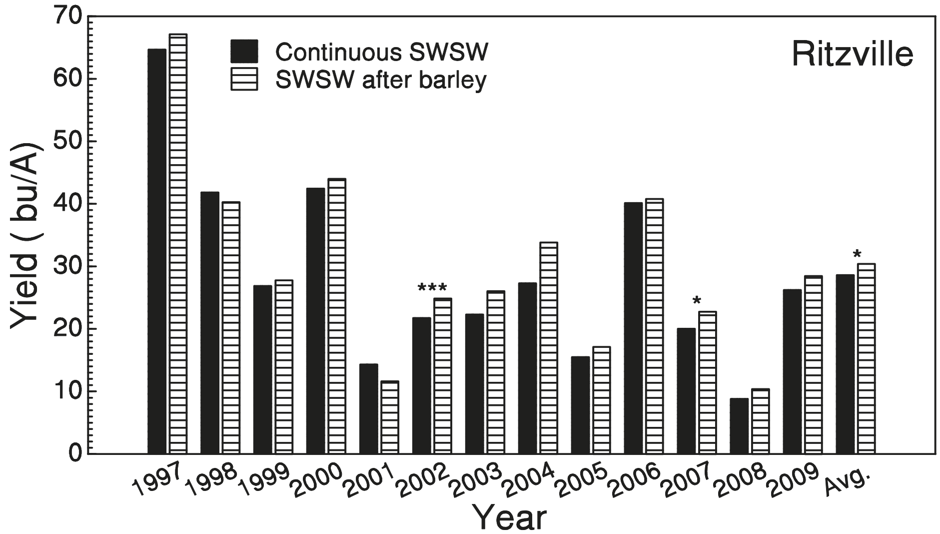

Fig. 1. Grain yield of continuous annual soft white spring wheat versus soft white spring wheat grown in a 2-year rotation with spring barley in a long-term dryland no-till cropping systems experiment near Ritzville, WA. * and *** indicate significant statistical differences at the 0.05 and 0.001 probability levels, respectively.

Land Area Devoted to Dryland and Irrigated Cropping in the Inland Pacific Northwest

W.F. SCHILLINGER, DEPT. OF CROP AND SOIL SCIENCES, WSU

Type of Farming	State†	Acres
1. Dryland		
Low (< 12 inches) ‡	Washington	3,021,000
	Oregon	825,000
Intermediate (12 to 18 inches)	Washington	1,534,000
	Oregon	798,000
	Idaho	62,000
High (18 to 24 inches)	Washington	944,000
	Idaho	924,000
	Oregon	163,000
2. Irrigation from rivers	Washington	1,203,000
	Oregon	178,000
3. Irrigation from deep wells	Washington	151,000
	Oregon	64,000

† Total dryland crop acres by state in the Inland PNW: Washington 5,498,000; Oregon 1,786,000; Idaho 985,000. Total irrigated crop acres by state in the Inland PNW: Washington 1,354,000; Oregon 242,000. These are 2008 data gleaned from the National Agricultural Statistics Service, USDA, Washington, DC.

‡ Numbers in parenthesis are average annual precipitation.

Improving Winter Wheat Seedling Emergence from Deep Planting Depth

AMITA MOHAN, KULVINDER GILL, WILLIAM SCHILLINGER, PATRICK REISENAUER, TIMOTHY SMITH, AND STEVE SCHOFSTOLL, DEPT. OF CROP AND SOIL SCIENCES, WSU

About two million dryland farm acres in eastern Washington receives less than 10 inches of annual precipitation. Winter wheat-summer fallow is a popular crop rotation in this region. Winter wheat is planted deep into tilled summer fallow soil to reach adequate moisture for germination and growth. Successful stand establishment from late summer planting directly effects grain yield and water use efficiency in this region. 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. Funded by the Washington Wheat Commission, objective of our project is to improve the emergence of the newly released soft winter wheat variety Xerpha. The cultivar Buchanan (red hard common) and Moro (soft white club) are being used as the trait donors during the transfer of 'good seedling emergence' into Xerpha using our recently optimized marker assisted background selection using which a gene can be transferred into a variety in just two backcrosses while recovering a very high percentage of recurrent parent background. Focusing on the Xerpha ´ Buchanan cross, about 14,000 BC1 seeds were developed. Evaluation of the first batch of 4000 BC1F1 seedlings showed a complex inheritance for the coleoptile length as only about 25% of the seedlings showed coleoptile length similar to that of the donor parent. Furthermore, in order to identify additional sources of good seedling emergence, 667 lines from our world collection were evaluated at Lind for emergence from deep planting. These lines were also evaluated for their coleoptile length. Top ten lines from both experiments (longest coleoptile and fastest emerger) were further evaluated for emergence in pot experiments. In order to identify the best emerging line from deep planting depths, the top eight lines from the pot experiment will be evaluated in further pot experiments at four different water potentials.

Critical Water Potential for Wheat Germination

Hesham Abdou, Prabhakar Singh, Markus Flury and W. F. Schillinger, WSU

The Horse Heaven Hills in South-central Washington is one of the low-precipitation (<300 mm annual) region where rainfed wheat farming is practiced. The climate is Mediterranean and the major cropping system is 2-yr winter wheat-summer fallow rotation. The fallow period following harvest conserves water in the seed zone. Tillage is performed in late spring to conserve the water during summer for planting in late August or early September. Water potential and temperature play an important role in seed germination. Water stress due to low water potential can significantly reduce and/or delay seed germination. Winter wheat is routinely planted deep into the seed-zone of summer fallow to ensure the presence of adequate soil moisture for germination. The time and depth of seed placement can be decided more accurately if the critical water potential for winter wheat seed germination is known. The objective of our study was (1) to determine the critical water potential required for seed germination for selected winter wheat varieties. A germination experiment was carried out in the laboratory at a controlled temperature of 20°C. Five winter wheat cultivars (Buchanan, Eltan, Finley, Moro and Xerpha) were selected. The selected water potentials were: -0, -0.25, -0.5, -0.75, -1.0, -1.25 and -1.5 MPa. Various amounts of Polyethylene glycol (PEG) were mixed with water to obtain different water potential solutions. We determined a calibration function relating PEG concentrations to water potential. Twenty seeds of each wheat variety with four replicates were placed into a Petri dish (90 mm diameter x 15 mm height) filled with two filter papers saturated with PEG solutions. Seed germination was inspected at 12-hour intervals, and seeds with 5 mm long coleoptiles were considered germinated. We observed that the Moro germinated faster than the other varieties under lower water potentials.

Seed Zone Water Content and Potential in the Horse Heaven Hills

Prabhakar Singh, WSU; Markus Flury and W. F. Schillinger, WSU

The Horse Heaven Hills in south-central Washington has a Mediterranean-like climate that receives only 150 to 215 mm average annual precipitation. The Horse Heaven Hills is one of the world's driest region for non-irrigated wheat farming. The 2-yr winter wheat-summer fallow rotation is dominant in this region. Planting in late august with stored water from winter precipitation increases grain yield and straw production. The climate in the Horse Heaven Hills, however, is often so dry that even with tillage-based summer fallow, farmers cannot maintain adequate seed-zone moisture and have to wait until the onset of rain in mid October or even later to plant winter wheat. In such years, farmers would be better off practicing chemical fallow; however, no predictive tools are currently available to assist farmers in these decisions. The objectives of our study were (1) to predict seed-zone water content and water potential in fall based on the measured water content in previous spring under conventional tillage and chemical fallow, and (2) to compare seed-zone moisture in conventional tillage and chemical fallow cropping systems, and (3) to evaluate the effects of timing of tillage operations on soil moisture. Replicated field plots (61 m by 18 m) were established for conventional tillage and chemical fallow treatments for wheat-fallow cropping systems at two farms at the Horse Heaven Hills. Soil physical properties and residue parameters were determined for modeling purposes as well as soil water contents were measured in both spring and fall during 2006 to 2009. Soil properties and residue loads were used as input parameter in the Simultaneous Heat and Water model (SHAW) for modeling seed-zone water. The SHAW model was used to predict seed-zone moisture in fall based on measured water contents in spring.

Rodweeding Not Required to Maintain Seed-Zone Moisture in Summer Fallow

W.F. SCHILLINGER, S.E. PETRIE, S.B. WUEST, T.A. SMITH, AND S.E. SCHOFSTOLL, WSU, OREGON STATE UNIVERSITY, AND USDA-ARS PENDLETON, OR

We are now in the final year of a 4-year field study at the WSU Dryland Research Station to evaluate the frequency of rodweeding operations on seed-zone moisture retention and several other agronomic and environmental factors. An identical 2-year study was also conducted at the OSU Sherman Experiment Station at Moro, OR. In mid April, primary spring tillage is conducted to a depth of 5 inches with a Haybuster undercutter sweep. Aqua nitrogen fertilizer is injected into the soil with the undercutter implement during the one-pass primary tillage. Subsequent rodweeding operations are conducted at the 4-inch depth with a Calkins center-drive rodweeder. Treatments are: (i) no rodweeding (i.e., check), weeds are controlled with a glyphosate herbicide with a sprayer as needed to maintain weed-free plots; (ii) rodweed only when required to control weeds (this ranges from 1 to 3 rodweedings depending on the year, but only one rodweeding was required in 2006, 2007, 2008, and 2009); (iii) rodweed immediately after primary spring tillage, but thereafter only as required to control weeds (as per treatment no. ii, above); and (iv) rodweed immediately after primary spring tillage and then at 3-week intervals until late July-early August, making a total of five rodweedings.

Results for 2006 through September 2009 show that primary spring tillage alone (in this case mid April with a Haybuster undercutter sweep) was all that was required to retain seed-zone moisture (data not shown). Rodweeding was not required to "set the moisture line". Surface clod mass was greatest in the undercut only (i.e., control) and the 1x rodweeding treatments. These data show that seed-zone moisture was not reduced by having a moderate quantity of soil clods on the surface of, and within, the soil mulch.

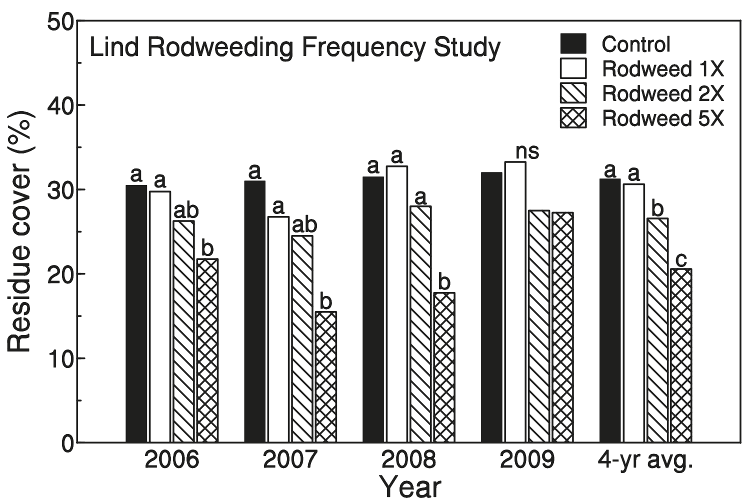

Fig. 1. Residue cover in the field after planting winter wheat as affected by previous rodweeding frequency during fallow in 2006, 2007, 2008, and 2009.

An average of slightly more than 30% residue cover was retained on the surface after planting winter wheat with deep-furrow drills in the control and 1x treatments (Fig. 1). This 30% residue cover after seeding has extremely important implications for farmers who participate in EQIP program because they are required to retain this amount of residue cover to receive their government payment. We plan to publish these data as well as data from related field studies in scientific journal articles and extension publications in the near future.

Comparative Performance of Low and High Disturbance No-Till Drill Openers for Establishing Crops into Wheat Residues

DEREK APPEL AND DAVE HUGGINS, USDA-ARS, PULLMAN, WA

Wheat residues greatly influence seed-zone temperature and water environments and can be a major barrier to no-till seeding of subsequent crops in dryland agricultural regions of the Pacific Northwest (PNW). At the Palouse

Conservation Field Station near Pullman, WA, we evaluated crop emergence patterns of canola and pea sown directly into wheat stubble during two fall and spring seasons using three types of no-till drill openers: inverted T (IT, Cross-slot®), double disk (DD) and hoe. In addition, broadcast seeding methods were evaluated for fall canola, spring canola and spring mustard. Seed-zone temperature, water, rates of emergence and final stands were monitored. Weibull function parameters were used to assess seedling emergence characteristics under the different drill opener treatments in addition to final crop emergence values. The data show that fall seed-zone conditions are generally more variable with respect to temperature, water and other factors influencing seed emergence than spring conditions, and are subject to greater drill opener effects. The Weibull function B parameter, a measure of how rapidly the crops emerge, indicated that DD and IT generally out-performed Hoe openers particularly under more marginal temperature and soil water conditions. In contrast, overall ranking of drill opener effects on final stands (fraction of final stand counts divided by seeds sown) averaged across crop and year was Hoe (0.48) > IT (0.41) > DD (0.38). Specific rankings, however, were highly influenced by crop and year indicating that one opener type will likely not achieve the best results under the diverse seeding environments typically found in dryland cropping regions of the PNW. Spring broadcast methods for establishing small seeded crops such as canola and mustard could be a viable option under NT and result in earlier stand establishment than drill methods as seed could be aerially applied.

Long-Term Conservation Tillage and Residue Additions at the Palouse Conservation Field Station, Pullman, WA

ANN C. KENNEDY, USDA-ARS PULLMAN, WA, TAMI L. STUBBS, WSU, JEREMY C. HANSEN, USDA-ARS PULLMAN, WA

One hundred years of agricultural production on the Palouse has depleted half of the native soil organic matter (SOM). Can this trend be reversed through management practices?Organic matter feeds soil microbes; provides nutrients to crops; holds water and contributes to aggregation. How much residue is needed to increase SOM? The objective of this study was to determine the effect of no-till and one-pass tillage (chisel) and various levels of residue on soil quality over time. Soil quality parameters were assessed to further define management practices that are soil building rather than degrading. Soil organic matter slowly increased in long-term no-till and chisel. The percentage of SOM in no-till research plots on a side slope at the Palouse Conservation Field Station increased from 1.9 percent to 3.6 percent in the top 7.5 inches over the course of 20 years. Soil organic matter increased to 3.2 percent when the soil was tilled with a one pass-chisel. Long-term no-till also increased the proportion of aggregates in the larger sized soil fractions. No-till stored a greater proportion of the soil carbon in the larger size aggregates, thus protecting more of the carbon from loss due to erosion when compared to nearby conventionally tilled sites. Long-term no-till results in changes to microbial communities and increases in the fungi:bacteria ratio. Data from these long-term experiments will allow us to better assess the productivity and quality of soils in the dryland cropping region of the Inland Pacific Northwest. This information will allow the identification of soil quality parameters that can be used in the development of best management practices for conserving soil quality and enhancing crop production.

Carbon Markets and Measuring Soil Organic Carbon Change at the Field-Scale

ROSS BRICKLEMYER, DAVID BROWN, DEPT. OF CROP AND SOIL SCIENCES, WSU

A key challenge for developing terrestrial carbon markets will be the ability to cost effectively and accurately verify soil organic carbon changes in response to changes in land management. The dispersed nature of agricultural carbon sequestration and soil spatial variation provide significant challenges for measuring soil carbon change (ΔSOC) across fields, landscapes and regions. Satellite remote sensing can be used to monitor and verify adoption of improved cropland management practices for individual farms across large regions. Given management practices, as well as information on soil types, climatic conditions and cropping systems, predictive biophysical soil carbon models (e.g. Century) can be used to estimate ΔSOC at the field scale. These models work well, on average, but rely upon data from controlled research on small plots measuring ΔSOC associated with specific practices (e.g. no-till, increased cropping intensity). However, these practice- and model-based estimates must be validated with representative ground-based ΔSOC measurements. Establishing benchmark sampling "microsites" for repeated SOC measurements over time is an efficient method for monitoring ΔSOC. Given that relatively few benchmark microsites can be cost-effectively monitored, they must be carefully located to be representative of larger areas. *In situ* visible & near infrared (VisNIR) spectroscopy is an established commercial technology capable of rapidly and inexpensively mapping soil properties that influence ΔSOC (e.g., current SOC stocks, texture and mineralogy). Thus, this technology could be used to select benchmark microsites. Laser-induced breakdown spectroscopy (LIBS) is an emerging elemental analysis technology with the potential to provide rapid and accurate analysis of soil constituents, such as carbon, with minimal soil preparation. As this technology matures, lab-based or field-deployable equipment could be employed to provide more cost-effective SOC measurements relative to standard laboratory techniques. Developing viable terrestrial carbon markets will require a synergistic approach using a combination of traditional soil sampling, predictive soil carbon models, satellite-based practice verification, and new SOC measurement technologies.

Investigating Soil and Landscape Variability in Soil Organic Carbon at the WSU Cook Agronomy Farm

TABITHA T. BROWN AND DAVID R. HUGGINS, DEPT. CROP AND SOIL SCIENCES, WSU AND USDA-ARS, PULLMAN, WA

Mitigation of rising greenhouse gases concentrations in the atmosphere has focused attention on agricultural soil organic C (SOC) sequestration. However, field scale knowledge of the processes and factors regulating SOC dynamics, distribution and variability is lacking. The objectives of this study are to characterize the soil profile (0- to 150-cm) and landscape variability in the distribution of SOC within a 37-ha Palouse field under agricultural management. A systematic, non-aligned grid of 177 geo-referenced sample locations was established at the Washington State University Cook Agronomy Farm (CAF) near Pullman, WA. Intact soil cores (0- to 153-cm) were collected, soils were described, classified, the surface divided into 0- to 30-cm increments and then by soil horizon to a depth of 153-cm and analyzed for soil bulk density and SOC. Profile (0- to 153-cm) SOC ranged from 54 to 272 Mg C ha^{-1} over the 37-ha field. The SOC content for the surface (0- to 30-cm) and subsurface (30- to 153-cm) ranged from 26 to 79 Mg C ha^{-1} and 14 to 193 Mg C ha^{-1}, respectively. Thatuna silt loams averaged 149 Mg C ha^{-1} followed by Palouse (125 Mg C ha^{-1}) and Naff (111 Mg C ha^{-1}) silt loam soil series. Landscape SOC redistribution via soil erosion was evident and erosion impacts on field SOC heterogeneity must be quantified if SOC sequestration and management impacts are to be adequately assessed. Furthermore, success in developing precision conservation strategies will require knowledge of site-specific processes and factors contributing to variability in soil productivity, SOC storage and nutrient dynamics.

Part 4. Bioenergy Cropping Systems Research

Progress of Washington State Biofuels Cropping Systems Project

W. PAN AND K. SOWERS, DEPT. OF CROP & SOIL SCIENCES, WSU

Biofuel demand and oilseed crop acreage is increasing annually in WA, and the need to provide growers with updated agronomic and production information for these crops is also increasing. After two crop years of research with the Biofuels Cropping Systems Research Project (see www.css.wsu.edu/biofuels), valuable data is being generated that is being utilized to inform growers, industry and other researchers about the potential of oilseed crop production in WA. Highlights of project progress to date include:

Rotation intervals for imazethapyr (marketed under the trade name Pursuit) may need to be increased based on data showing injury to oilseed crops beyond what current labels state.

Four camelina mutant populations have been identified with partial resistance to imi herbicides, and one with SU resistance, with no significant change in yield potential. Research this year will determine if a higher resistance level can be obtained.

We will continue to evaluate the potential of early-seeded winter canola for improved stand establishment and use as a forage and grain crop in eastern WA.

In dryland canola field studies, 80-90% of maximum yield was achieved without N fertilizer, which may lead to revision of current fertilizer N recommendations. Deep well irrigated canola and safflower were successfully grown in central WA with deficit irrigation and low N rates.

Camelina shows potential as an oilseed crop in the winter wheat-summer fallow region. The rotation it will most likely fit in is a 3-year winter wheat-camelina-summer fallow system.

Early (mid-August) planted winter canola produced high yields at Puyallup, with two times the yield as a mid-September planting. Low yields of camelina, mustard and flax at Mt. Vernon may be fertility related; cool, wet weather also has an impact on crop success.

Successful establishment and winter survival of upland versus lowland switchgrass varieties, as well as other warm season grasses, varies depending on planting date and soil temperature.

Introduction of Canola in the Okanogan Region of Washington for Economic and Agronomic Benefits

FRANK YOUNG, LAYLAH BEWICK, LARRY MCGREW, USDA-ARS, PULLMAN, WA; DENNIS ROE, DEPT. OF CROP AND SOIL SCIENCES, WSU

Pilot field studies on winter canola were launched in the fall of 2007 near Okanogan in response to a local grower's (Ed Townsend) interest in and request for research on dryland winter canola production in the Okanogan area. A field day was conducted in the spring of 2008 and the project was expanded in the fall of 2008 to include another grower-cooperator, Wade Troutman. A second field day was conducted on May 20 2009.

In 2007, seeding dates into chem. fallow plots were August 21 and September 4 at Okanogan. Seeding rates were 2, 4, and 6 lbs/A using a modified John Deer HZ deep furrow drill.

In 2008, seeding dates were August 12th and 25th for the Okanogan site where we looked at two different planting rates, 4 and 8 lbs/A. The planting methods and machinery used at this site were the same as the 2007 study

In 2009, seeding dates were August 19th and 31st for the Okanogan site where we looked at two different planting rates, 4 and 8 lbs/A. and 2,4, and 6 lbs/acre, respectively. The planting methods and machinery used at this site were the same as the previous two years. Plots will be harvested in July 2010 and crop yield and seed, oil, and meal (for feed) quality will be determined. Winter survival was fair to good at all locations. The plots seeded August 31st at the Townsend site were reseeded to spring canola.

The research results from these studies will be used by Colville Confederated Tribal landowners for growing canola for the Tribal oilseed crushing and bulk fuel plant installation planned an underway. The recent soil and crop survey by the Colville Confederated Tribes shows 100,000 acres of cropland on which Tribal members can produce canola.

Photograph taken February 10, 2010 shows control of feral rye on the right side of the picture in winter canola seeded August 19,2009. Treatment for rye was made October 15, 2009.

Evaluation of Camelina Varieties and Numbered Lines at Lind

W.F. SCHILLINGER, T.A. SMITH, S.E. SCHOFSTOLL, B.E. SAUER, AND B.J. FODE, DEPT. OF CROP AND SOIL SCIENCES, WSU, LIND

We are currently in the third year of multi-location camelina agronomy trials. Identical experiments are conducted in four precipitation zones in the Pacific Northwest. These locations are Lind, Pendleton (Don Wysocki, OSU), Pullman (Stephen Guy, WSU), and Corvallis (Tom Chastain, OSU). This brief report covers the performance of numerous camelina varieties and numbered lines during 2009 at Lind.

For the 2009 crop year, 18 camelina varieties and numbered lines were planted in the fall and 25 varieties and numbered lines were planted in the spring. We built a small-plot drill (using John Deere 450 double-disc openers on 6-inch row spacing) for this purpose. Camelina was sown into standing winter wheat stubble at a rate of 4 lbs/acre. Individual plots were 5 x 20 feet and all entries were replicated four times in a randomized complete block arrangement. Fall planting was conducted on November 19 and spring planting on February 27. Plots were fertilized with 25 lbs/acre of nitrogen.

Precipitation for 2009 crop year (Sept. 1 – Aug. 31) at the Lind Research Station was 8.46 inches. Long-term average crop-year precipitation for this site is 9.50 inches. Grain yields among entries ranged from approximately 400 to 600 lbs/acre for both fall and spring planting dates (Fig. 1). The variety 'Calena' was one of the top producers from both planting dates.

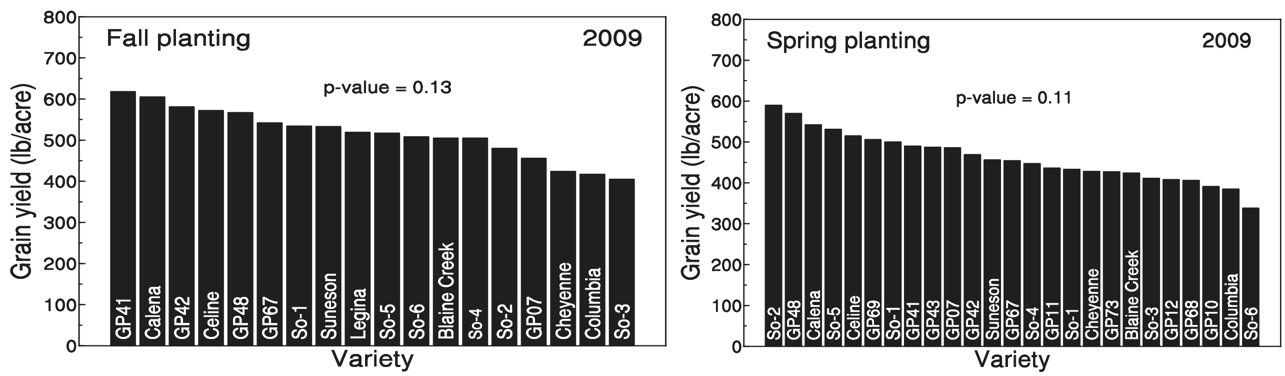

Fig 1. Grain yield of camelina varieties and numbered lines at Lind, WA in 2009. (Left) 18 camelina varieties and numbered lines were direct-drilled into wheat stubble on November 19, 2008. There were no significant grain yield differences among entries. (Right) 25 camelina varieties and numbered lines were direct drilled at Lind on February 27, 2009. There were no significant grain yield differences among entries.

Winter Canola Feasibility in Rotation with Winter Wheat

ESSER,* A.D., EXTENSION AGRONOMIST, WSU EXTENSION, LINCOLN-ADAMS AREA, RITZVILLE, WA, AND HENNINGS, R., WHEAT PRODUCER, ADAMS COUNTY, SPRAGUE, WA

Producers in the dryland (<12 inches annual precipitation) cropping region of eastern Washington continue looking for profitable alternatives to winter wheat (*Triticum aestivum* L.) to limit grassy weed resistance to Group 2 herbicides. Winter canola (*Brassica napus* L.) is an oil seed crop that offers non Group 2 grassy weed herbicide options but has a very limited history in this region as agronomic and economic risks are elevated. The objective of this research is to help producers determine market prices needed to minimize risks, increase profitability, and decrease potential for herbicide resistances. An on-farm test (OFT) was initiated in the fall of 2006 examining two treatments: 1. winter canola, summer fallow, winter wheat; 2. winter wheat, summer fallow, winter wheat. The OFT was a RCBD with 4 replications and was 6.5 acres in size. Total production costs between the two crops were similar. Winter wheat produced greater yield and gross economic return at 43.5 bu and $355/ac compared to canola at 34.5 bu and $293/ac. Subsequent winter wheat yield was 39.3% greater following canola and over the total cropping sequence, no significant difference in gross economic returns were determined between winter wheat and canola averaging $493/ac. In conclusion, yield differences were documented between winter wheat and canola but market price differential between the two crops has a larger influence on the profitability and can vary dramatically from year-to-year. Overall winter canola needs to have a 26.4% price advantage per bushel over wheat to produce significantly greater gross economic returns.

Camelina Planting Date and Planting Method Experiment at Lind

W.F. SCHILLINGER, T.A. SMITH, S.E. SCHOFSTOLL, AND B.E. SAUER, DEPT. OF CROP AND SOIL SCIENCES, WSU, LIND, WA

We are now in the third year of several camelina agronomy trials at Lind. For the planting date and planting method experiment, camelina is sown on several dates from October 15 through March 15. Two planting methods are used, either direct seed with a no-till drill or broadcast and lightly incorporate into the soil with a 5-bar tine harrow. Nitrogen at a rate is 25 lbs/acre is applied in early February. Poast™ herbicide is used in early spring to control downy brome and other grass weeds. Grain yield is determined using a plot combine. We replicate each treatment four times in a randomized complete block design. Each plot is 8 ft x 100 ft. Camelina is sown at a rate of 4 lbs/acre into standing winter wheat stubble.

Precipitation for 2009 crop year (Sept. 1 – Aug. 31) at the Lind Research Station was 8.46 inches compared to the long-term average of 9.50 inches. Camelina produced an average yield of about 500 lbs/acre (Fig. 1). The experiment was shown and discussed with 225 people who attended the Lind Field Day as well as with several individuals and groups who stopped by the Lind Station during the year. The same experiment is being conducted by Stephen Guy in Pullman, Don Wysocki in Pendleton, OR, and Tom Chastain in Corvallis, OR.

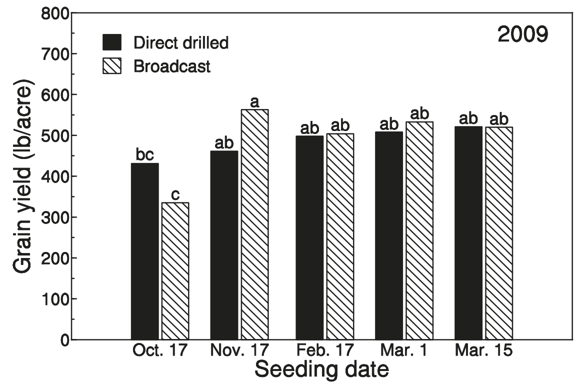

Figure. 1. Grain yield of camelina (cv. Calena) at Lind, WA in 2009 as affected by two planting methods and five planting dates. There were no significant differences in planting method on any individual date, but there were some relatively minor differences in grain yield as affected by planting date. We suspect that cold temperatures in December 2008 may have damaged the October 17 planting,, as this was the only planting that had emerged at that time. Means followed by the same letter are not significantly different at $P < 0.05$.

Site-Specific Trade-offs of Harvesting Wheat Residues for Biofuel Feedstocks

DAVE HUGGINS AND CHAD KRUGER, USDA-ARS, PULLMAN, WA AND THE WSU CENTER FOR SUSTAINING AGRICULTURE & NATURAL RESOURCES

Crop residues are considered to be an important lignocellulosic feedstock for future biofuel production. Harvesting crop residues, however, could lead to serious soil degradation and loss of productivity. Our objective was to evaluate trade-offs associated with harvesting residues including impacts on soil quality, soil organic C and nutrient removal. We used cropping systems data collected at 369 geo-referenced points on the 92 acre Washington State University Cook Agronomy Farm to aid our evaluation. Site-specific field estimates of lignocellulosic ethanol production from winter wheat residues (50% harvesting efficiency) ranged from 87 to 189 gallons/ac and averaged 145 gallons/ac suggesting that targeted harvesting of crop residues may be an important consideration. Harvesting winter wheat residues reduced remaining residue C inputs to levels below that required to maintain soil organic C under conventional tillage practices. This occurred as a function of both residue removal and the inclusion of a low residue producing spring pea crop in rotation with wheat. Harvesting winter wheat residues under conventional tillage resulted in negative Soil Conditioning Indices (SCI) throughout the field. In contrast, SCI's under no-till were positive despite residue harvesting. The value of nutrients harvested in each ton of wheat straw was \$13.48/ton assuming N @ \$0.50/lb; P_2O_5 @ \$0.60/lb; K_2O @ \$0.30/lb and S @ \$0.40/lb. Field average amounts of nutrients removed in harvested wheat residue were N: 14 lb/ac; P_2O_5: 6 lb/ac; K_2O: 33 lb/ac; and S: 3 lb/ac valued at \$21.70/ac. Across the field, the estimated value of harvested residue in fertilizer replacement dollars ranged from \$17.99 to \$28.24/ac. We concluded that substantial trade-offs exist in harvesting wheat straw for biofuel, that trade-offs should be evaluated on a site-specific basis, and that support practices such as crop rotation, reduced tillage and site-specific nutrient management need to be considered if residue harvest is to be a sustainable option.

Washington State University Extension

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 Sate 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 location 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.

Rob Dewald, Wilke farm cooperator, direct seeds “Scarlet” DNS wheat at the WSU Wilke Research and Extension Farm in 2010.

Photo by Aaron Esser