Note to the reader:

A few of these abstracts, those preceded by an asterisk in the Table of Contents, have full-length articles associated with them.

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WASHINGTON STATE UNIVERSITY
EXTENSION

2007 Field Day Abstracts:

Highlights of Research Progress

"Novel Solutions to Traditional Problems"

Dedicated to Dr. R. James Cook

Department of Crop and Soil Sciences
Technical Report 07-1

WSU Lind Dryland Research Station Field Day
Lind — June 14, 2007

WSU Cook Agronomy Farm Field Day
Pullman — June 28, 2007

WSU Spillman Agronomy Farm Field Day
Pullman — July 12, 2007

Welcome to our 2007 Field Days!

As the Chair of the Department of Crop and Soil Sciences, I am proud to introduce the 2007 Field Day Abstracts: Highlights of Research Progress. This publication has a simple purpose: to introduce you to over 35 research programs conducted in 2007 by WSU faculty and USDA-ARS research scientists working as part of, or in cooperation with, the Department of Crop and Soil Sciences.

This year's theme is "Novel Solutions to Traditional Problems." Herein you will learn about the breadth of novel solutions as applied to variety development, crop production, and sustainability. These solutions will be emphasized at the field days with presentations, demonstrations, and an exciting marker-assisted selection workshop following Spillman Agronomy Farm field day. We will also celebrate the naming of Cook Agronomy Farm, in honor of Dr. R. James Cook, with a special dedication at the Cook Agronomy Farm field day on June 28th.

The Department of Crop and Soil Sciences mission states that we will "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; and disseminate accumulated knowledge through resident instruction, continuing education, extension, publications, and professional contacts."

As you will read in the abstracts, we have exciting new and ongoing research activities. Our 2007 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. William L. Pan, Chair
Dept. of Crop & Soil Sciences

Dedicated to Dr. R. James Cook

Dr. R. James Cook, retired July 31, 2005 after 40 years of service to Washington State University and the Agricultural Research Service.

Cook served as interim dean of the College of Agricultural, Human, and Natural Resource Sciences at Washington State University (WSU) since July 2003. He held the R. J. Cook Endowed Chair in Wheat Research at WSU since April 1998, a position endowed by the Washington Wheat Commission. From 1965 to 1998, he was a USDA-ARS research plant pathologist in the Root Disease and Biological Control Research Unit in Pullman, with a joint appointment on the WSU faculty, conducting research on biological approaches to control root diseases of Pacific Northwest wheat. He completed his B.S. and M.S. degrees at North Dakota State University in 1958 and 1961, and his Ph.D. at the University of California-Berkeley in 1964.

"Dr. Cook's career has been one of superlatives. He is a member of both the National Academy of Sciences and U.S. Department of Agriculture Agricultural Research Service Science Hall of Fame. He is a fellow of the American Association of Advancement of Science, an International Society for Plant Pathology past president, and has authored more than 200 scientific articles," said WSU President V. Lane Rawlins during presentation of the President's Distinguished Lifetime Service Award in April, 2005. Cook is also a Fellow in the American Phytopathological Society, the Crop Science Society of America, and the American Society of Agronomy.

In retirement Cook plans to write another book and remain involved as an advocate for agriculture. He and his wife Bev will divide their time among a north Idaho lake home, western Washington, and four children.

"The Rest of the Story"
Invited commentary by Dr. R. James Cook

It is a distinct honor after four decades of participating in WSU field days to be invited to write this commentary for the 2007 Field Day Abstracts: Highlights of Research Progress with the theme *"Novel Solutions to Traditional Problems."* All four root diseases that became the focus of my program—Fusarium root and crown rot, take-all, Rhizoctonia root rot, and Pythium root rot—are *traditional problems,* having been described in the scientific literature in the first half of the 20th century. Regarding the need for *novel solutions*, consider that breeding for resistance has played almost no role in their control, the use of fungicides has been limited to seed treatments that provide little or no protection for roots, and only take-all can be controlled by crop rotation, preferably with an impractical two years between cereal crops. Add no-till, with crop residue left like a wet blanket on the soil surface and infested root and crown tissues of the previous crop left undisturbed in the top few inches of soil until planting and the need for *"novel solutions"* takes on a new meaning.

Of all the advances in root disease management of the past 40 years, none is more novel than the discovery and exploitation of the spontaneous decline in take-all with continuous wheat and barley sequences. For this commentary, **I have chosen to tell the novel story behind the story of take-all decline.**

The results of an early, defining and part of a three-year-long winter wheat monoculture experiment are illustrated on the cover of this brochure. Dr. Peter Shipton from the United Kingdom had joined me for two years starting in early 1969, and together we set out to see whether a factor or factors responsible for take-all decline could be transferred from one field to another. The late Elvin Kulp, Extension agronomist for Grant County, pointed us to a field near Quincy that was in the 12th year of monoculture winter wheat, with no take-all in spite of irrigation known to favor this disease. Shipton, Richard Smiley (plant pathologist at Oregon State University—then my PhD student), and I loaded garbage cans with soil from that field and soil from an adjacent site still under sage brush and hauled it to the WSU station at Puyallup in the fall of 1969. There, we sprinkled these and several other soils onto replicate plots, roto-tilled the plots to a depth of six inches, and planted winter wheat with the take-all fungus introduced as colonized oat grains mixed with a high-quality wheat seed in the drill box. The actual amount of introduced soil mixed into the plots amounted to only about 0.5% by weight.

The first crop was devastated by take-all, with no benefit of added soil. The picture at the right (and on the back cover) shows plants dug from the plots in April, 1971, which represented the second wheat crop produced with wheat seed only (depending entirely on the abundant carry over inoculum of the take-all fungus). Take-all was virtually nonexistent in all four (and only these four) replicate plots where soil from the Quincy wheat field had been added 18 months earlier (plants on the right), but was still severe in plots with no soil amendment (left) or amended with soil from the non-cropped site next to the 12-year-monoculture wheat field (center). The wheat was uniformly healthy border to border in the third year, in spite of the large amount of carry over pathogen inoculum. Clearly, something in soil from the field in continuous wheat monoculture was suppressive to take-all, was transferable and it could multiply. Also with this experiment, we knew that take-all decline was not some figment of our imagination.

Thanks to world-class research by USDA-ARS scientists David Weller and Linda Thomashow, as well as their graduate students, post-doctoral associates and technical assistants, take-all decline is now understood to result from one or a select few genotypes of root-associated bacteria of *Pseudomonas fluorescens* that 1) inhibit the take-all pathogen by production of the antibiotic 2,4-diacetylphloroglucinol (DAPG), and 2) buildup in response to one or more outbreaks of take-all and continuous monoculture of wheat and barley. In a symbiotic way, these novel bacteria, responding to an ecological niche obviously to their benefit, team up with and protect roots so as to give the equivalent of disease-resistant plants. At last count, 22 distinct genotypes of DAPG-producing *P. fluorescens* bacteria have been identified world-wide, with just one of these 22 genotypes consistently associated with take-all decline in Washington. a More recent studies suggest that other DAPG-producing genotypes, or strains with ability to produce other antibiotics, tend to respond spontaneously to other crops and cropping systems. Considering the diversity of these root-associated bacteria as revealed by the DAPG-producing genotypes, one can only imagine the permutations and combinations of crop and root-associated bacteria and their roles in sustaining yields that otherwise could only be achieved with a more traditional long and diverse crop rotation.

Never imagining where this research would lead, looking back, it provided justification for hiring David Weller in 1979, Linda Thomashow in 1985, and establishment of the USDA-ARS Root Disease and Biological Control Research Unit at Pullman in 1984. It also provided a model system for a modernized science of biological control of soilborne plant pathogens; clues to the success of intensive cropping systems as illustrated with monoculture cereals; and the centerpiece of an integrated approach to management of all four root diseases in cereal-intensive direct-seed cropping systems that includes timely green bridge management, fertilizer placement with some soil disturbance and trash clearance in the seed row, and use of fresh seed protected against *Pythium*.

Near Pullman, Washington, (left to right) Kurtis Schroeder, Linda Thomashow, Jim Cook, and David Weller examine healthy wheat thriving in a field infected by the fungus that causes wheat take-all.

While research on Fusarium, Rhizoctonia, and Pythium has been supported for some three decades by the Washington Wheat and Barley Commissions, research on take-all decline has been funded during these same three decades by the USDA competitive grants program—starting with my first grant in 1978 which allowed me to hire David Weller. Aspects of this research were carried out in cooperation with growers in six counties (Grant, Skagit, Spokane, Walla Walla and Whitman in Washington, and Umatilla in Oregon) and on six WSU research farms (Lind, Mt. Vernon, Palouse Conservation Field Station, Plant Pathology, Puyallup, Spillman). An experiment on Spillman Agronomy Farm with bacteria-treated winter wheat in 1987-88 involved an antibiotic-producing strain engineered to express a color marker and represented the first field release of a genetically engineered organism in the Pacific Northwest. The longest running experiment is on the Lind station where winter and spring wheat sequences have grown continuously under irrigation since 1967; take-all was severe but declined between the seventh and the 15th years. Two of the six cropping systems on the Cook Agronomy Farm include continuous winter and spring wheat and barley sequences, done on a commercial scale with no-till.

As Paul Harvey would say, "now you know the rest of the story."—*R. James Cook*

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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	Dean and Director, WSU Extension
Ralph P. Cavalieri	Associate Dean and Director, Agricultural Research Center
William L. Pan	Chair, Dept. 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
K. Gill ....335-4666 .... ksgill@wsu.edu
S.S. Jones ....335-6198 .... joness@wsu.edu
K.K. Kidwell ....335-7247 .... kidwell@mail.wsu.edu
D.R. See, USDA ....335-3632 .... deven.see@wsu.edu
C. Steber, USDA ....335-2887 .... csteber@wsu.edu
S.R. Lyon, K. Balow, M. Gollnick, K. Murphy, G.B. Shelton, V.L. DeMacon, M. Santra, A. Burke, D. Santra, A. Carter, N. Blake, J. Chatelain, C. Hoagland, L.M. Little, L. Murphy, G. Poole, L. Reddy

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
V.A. Jitkov, J.S. Cochran, A. Del Blanco, H. Lee, P. Reisenauer

Crop Diseases

Cereal Cephalosporium Stripe, Foot Rots & Snow Molds

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

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, R. Sloot, R. Davis

Rusts, Smuts; Foliar, Virus and Bacterial Diseases

L. Carris ....335-3733 .... carris@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
L. Penman; D.A. Wood, USDA

Wheat Quality

Wheat Quality

B. Baik .... 335-8230................................ bbaik@wsu.edu
T. Harris

USDA Western Wheat Quality Lab

C.F. Morris, Cereal Chemist/Director ....335-4062 .... morrisc@wsu.edu
B. Beecher, A.D. Bettge, D.A. Engle, M.L. Baldridge, G.E. King, G.L. Jacobson, W.J. Kelley, M.J. Freston, P.K. Boyer, E. Wegner, B. Paszczynska, S. Sykes, J. Luna

WSU Extension Uniform Cereal Variety Testing

J. Burns ....335-5831 .... burnsjw@wsu.edu
J. Kuehner, A. Horton

(Continued on page 6)

Breeding and Culture of Legumes

Dry Peas, Lentils, Chickpeas

W. Chen, USDA .... 335-9178 .... w-chen@mail.wsu.edu
K.E. McPhee, USDA .... 335-9522 .... kmcphee@mail.wsu,edu
F.J. Muehlbauer, USDA .... 335-7647 .... muehlbau@wsu.edu
J. Pfaff, S.L. McGrew, L. Burns

Dry Beans

A.Hang .... 509-786-9201 .... ahang@tricity.wsu.edu
P. Miklas, USDA .... 509-786-9258 .... pmiklas@tricity.wsu.edu

Weed Management

I. Burke .... 335-2858 .... icburke@wsu.edu
P. Fuerst .... 335-7850 .... pfuerst@wsu.edu
J. Yenish .... 335-2961 .... yenish@wsu.edu
F.L. Young, USDA .... 335-4196 .... youngfl@wsu.edu

Conservation Systems, Fertility Management and Biofuels

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. Koenig .... 335-2726 .... richk@wsu.edu
H. Kok .... 208-885-5971 .... hanskok@wsu.edu
D. McCool, USDA .... 335-1347 .... dkmccool@wsu.edu
W.L. Pan .... 335-3611 .... wlpan@wsu.edu
R.D. Roe, USDA .... 335-3491 .... rdroe@wsu.edu
W.F. Schillinger .... 509-235-1933 .... schillw@wsu.edu
J. Smith, USDA .... 335-7648 .... jlsmith@mail.wsu.edu

Soil Microbiology

A.C. Kennedy, USDA .... 335-1554 .... akennedy@wsu.edu
T.L. Stubbs, J.C. Hansen

Agricultural Economics

D.L. Young .... 335-1400 .... dlyoung@wsu.edu
K. Painter

WSCIA Foundation Seed Service

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

Field Stations

Spillman Agronomy Farm

S. Kuehner, Farm Manager .... 335-3081 .... skuehner@wsu.edu

Cook Agronomy Farm

R. Davis, Farm Manager .... 335-8715 .... 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

R. Stevens, Interim Director .... 509-786-9231 .... stevensr@wsu.edu

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Cooperators

Aeschliman, John /Cory—Colfax
Anderberg, Al—Fairfield
Appel, Steve—Dusty
Ashburn, Douglas—Genesee/Uniontown
Bauermeister, Dale/Dan—Connell
Boyd, Pat—Pullman
Broughton Land Co.—Dayton
Bruce, Albert/Doug—Farmington
Brunner, Rick—Almira
Burress, Randy—Moses Lake
Camp, Steve—Dusty
CBARC—Pendleton, OR
Covington, Larry—Nespelem
Craigs, Walter—Palouse
DeLong, Sara/Joe—St. John
Dewald, Rob—Ritzville
Dietrich, Dale—Reardan
Dobbins, Glenn/Bryan—Four Lakes
Dozier, Perry—Waitsburg
Druffel, Leroy—Uniontown
Druffel, Norm/Sons—Pullman
Druffel, Ross/Phil—Colton
Els, Jim—Harrington
Emtman, Randy/Jeff—Rockford
Ericksen, Tracy—St. John
Evans, Jim—Genesee
Felgenhauer, Karl—Fairfield
Fleming, Chad—Lacrosse
Ford, Allen—Prescott
Glasco, Paul—Moses Lake
Green, Lonnie—Fairfield
Gross, Paul/Jake—Deep Creek
Harlow, David—Pullman
Haugerud, Nick—Colfax
Hauser, Gary—Pomeroy
Heimbigner, Ross—Ritzville
Hennings, Curtis/Erika—Ralston
Hennings, Ron—Ritzville
Herdrick, Tim—Wilbur
Herron, Chris—Connell
Hirst, Jim—Harrington
Idaho, Univ. Kambitsch Farms—Genesee, ID
Jacobsen, Adelbert/Neil—Waterville
Jirava, Ron—Ritzville
Johnson, Frank/Jeff—Asotin
Johnson, Hal—Davenport
Jones, Rick—Wilbur
Jorgensen, Keith/Owen—St. Andrews
Knodel, Jerry—Ralston
Koller, Randy/Roger—Pomeroy
Kramer, Mark—Harrington
Krause, Jerry—Creston
Kuehner, Steve—Pullman
Kupers, Karl—Harrington
LaFave, John—Moses Lake
Laney, Chris—Sprague
Lange, Frank—Palouse
Leahy, Ed—Walla Walla
Lyons, Rusty—Waitsburg
Mader, Dan—Genesee/Uniontown
Mader, Steve—Pullman
Madison, Kent—Hermiston, OR
Maier, Eric—Ritzville
Mains, Tony—Mabton
Matsen, Steve—Bickleton
McKay, Dan—Almira
McLean, Dean/Bill—Coulee City
Mills, Mac/Rod—St. John
Monson, Jason—Lacrosse
Moomaw, Cherie—Omak
Moore, Jim/Ann—Kahlotus
Moore, Steve/Dan—Dusty
Nelson, Bruce—Farmington
Nichols, Mike—Horse Heaven Hills
Niehenke, Norbert/Kent—Colton
Ostheller, David—Fairfield
Pearson, Dave—Horse Heaven Hills
Pennell, Roger—Garfield
Penner, Jay—Dayton
Pfaff, Richard—Farmington
Pottratz, Dennis—Fairfield
Rausch, Chris—Lexington, OR
Repp, Randy—Dusty
Richter, Mark—Endicott
Roseberry, Dave—Prosser
Sauer, Bruce—Lind
Schafer, Derek—Ritzville
Schmitt, Mike/Dan—Horse Heaven Hills
Schmitz, Joe—Rosalia
Schoesler, Mark—Ritzville
Sheffels, Mark—Wilbur
Snyder, Jerry—Ralston
Stubbs, Jerry/Mike—Dusty
Suess, Randy—Colfax
Swannack, Steve—Lamont
Takemura, Jay—Dayton
Tanneberg, Jason—Mansfield
Tanneberg, Larry—Coulee City
Tee, Larry—Latah
Thorn, Eric—Dayton
Tiegs, Brian—Fairfield
Torrey, Grant—Moses Lake
Welch, Ron—Moses Lake
Wesselman, Roger—Mansfield
White, Gil—Lamont
Wirth, Bill—Moss Lake
Zenner, Russ—Genesee

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CONTRIBUTORS

Agri-Pro
Agrium
Amen Endowment, Otto & Doris
American Malting Barley Assn.
Andersen Machine Inc.
Arizona Plant Breeders
BASF
Bayer Corp.
BNP Lentil
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BNP Lentil
Busch-Ag Resources
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Co-Ag, Inc.
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Columbia Grain Int'l.
Connell Grain Growers
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Washington Wheat Commission
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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 3 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 90-acre watershed using 369 GPS-referenced sites on a nonaligned grid. Maps are available or being developed from archived samples for soil types and starting weed seed banks, populations of soilborne pathogens, and soil water and nitrogen supplies in the profile. 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 systems (rotations) starting in the fall of 2001. Yield and protein maps were produced for the crops produced in 1999 and 2000.

The 90-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.

History of the 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 has the lowest rainfall of any state or federal facility devoted to dryland research 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. The primary purpose of irrigation on the Dryland Research Station is not to aid in the development of wheats for higher rainfall and irrigated agriculture, but to speed up and aid in the development of better varieties for the low-rainfall dryland region.

Dr. M. A. McCall was the first superintendent at Lind. McCall was a gifted researcher given somewhat to philosophy in his early reports. In a 1920 report he outlined the fundamental reasons for an outlying experiment station. He stated: "A branch station, from the standpoint of efficiency of administration and use of equipment, is justified only by existence of a central station." The Lind station has followed the policy of studying the problems associated with the 8-to 12-inch rainfall area.

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. A pump and irrigation system were installed in 1967. A new seed processing and storage building was completed in 1983 at a cost of $146,000. The Washington Wheat Commission contributed $80,000 toward the building, with the remaining $66,000 coming from the Washington State Department of Agriculture Hay and Grain Fund. A machine storage building was completed in 1985, at a cost of $65,000, funded by the Washington Wheat Commission.

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. Also in 1996, the state of Washington transferred ownership of 1000 acres of adjoining land 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 was established as one of 10 original erosion experiment stations throughout the United States during the period 1929 to 1933. The station consists of a number of buildings including offices, laboratories, machine shop, a greenhouse, and equipment buildings, as well as a 200-acre research farm. Scientists and engineers from the USDA/ARS and Washington State University utilize the Station 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. Several persons are employed at the Station by both the federal and state cooperators. The Station has a full-time manager who lives on-site and maintains the busy flow of activities which characterize the farm. This includes the day-to-day routine items, farm upkeep, maintaining the complex planting and harvest schedule to meet the requirements of the various cropping research, and operating the machine shop which fabricates a majority of the equipment used in the research projects. There are also a number of part-time employees, many of whom are graduate students, working on individual projects. Along with the many research projects, a no-till project at the Palouse Conservation Farm was initiated on bulk ground in the fall of 1996. The objective of this project is to determine if it is technologically possible and economically feasible to grow crops in the eastern Palouse under no-till. The ARS Units at Pullman are focusing on technologies and research needed to make no-till farming possible in this region.

History of Spillman Agronomy Farm

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

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

Through the initiative of Dr. Orville Vogel, USDA Wheat Breeder at WSU, and the dedicated efforts of many local

William J. Spillman, breeding plots at Pullman, 1900 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.

Variety History at WSU

Wheat Varieties

COMPILED BY STEVE LYON

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

SPILLMAN

Variety	Year Released	Market Class	Background / Named After
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

Variety	Year Released	Market Class	Background / Named After
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

Variety	Year Released	Market Class	Background / Named After
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

Variety	Year Released	Market Class	Background / Named After
McCall	1965	HRW	M.A. McCall, first superintendent of Lind Station
Wanser	1965	HRW	HM Wanser, early dryland agronomist

ALLAN

Variety	Year Released	Market Class	Background / Named After
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 and pwdry 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

Variety	Year Released	Market Class	Background / Named After
Sprague	1972	SWW	Rod Sprague, WSU plant pathologist. First snowmold resistant variety for WA

PETERSON

Variety	Year Released	Market Class	Background / Named After
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 dveloped 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	SWW	Nickname of the Breeder's neice
Otis	2004	HWS	Nickname of the Breeder's nephew

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

CAMPBELL

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

Barley Varieties

COMPILED BY STEVE ULLRICH

Name	Year	Market Class	Breeder	Comments
Olympia	1937	winter, 6-row, feed	Gaines	introduction from Germany collected in 1935
Rufflynn	1939	spring, 6-row, feed	Barbee	selection from Flynn (Club Mariout / Lion)
Belford	1943	spring, 6-row, hay	Barbee	selection from Beldi Giant / Horsford

Velvon 17	1947	spring, 6-row, feed	Gaines	selection from Velvon Composite 1 (Colorado 3063 / Trebi)
Heines Hanna	1957	spring, 2-row, malting	Gaines	introduction from Germany collected in 1925 (selected From a Czech landrace)
Luther	1966	winter, 6-row, feed	Nilan	induce mutant of Alpine (first induced mutant variety released in North America)
Vanguard	1971	spring, 2-row, malting	Nilan	selection from Betzes / Haisa II // Piroline
Kamiak	1971	winter, 6-row, feed	Nilan	selection from Bore / Hudson
Steptoe	1973	spring, 6-row, feed	Nilan	selection from WA 3564 (sel. From CC V) / 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

COMPILED BY FRED MUEHLBAUER AND KEVIN MCPHEE

The grain legume industry started in the early 1900s and progressed from using relatively old landraces to more advanced varieties produced by breeding programs. Initially, dry peas were produced from varieties that were commonly used for canning of fresh peas. Such varieties as 'Small Sieve Alaska', 'Alaska', 'First and Best' were commonly grown. These varieties gave way to 'Columbian', which is still the industry standard for color quality, and the so-called "stand-up varieties" such as 'Stirling'. Numerous varieties of the so-called stand-up peas have been developed and are in use for dry pea production. Lentil production began in the early 1920s on a small scale in the Farmington area and increased rapidly in the 1950s and 1960s. Varieties grown initially were described as "Persians" and "Chilean" types. The variety 'Brewer' released in 1984 quickly became the industry standard for the Chilean type. Other varieties such as 'Pardina', 'Redchief', 'Crimson', 'Pennell' and '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.

<u>Spring Yellow Peas</u>

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.

<u>Winter Peas</u>

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

<u>Brewer Types</u>

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.

<u>Laird Types</u>

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.

<u>Small-seeded Types</u>

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

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

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

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

Turkish Red Types

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

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

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

CHICKPEAS

Kabuli Type

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Desi Type

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

Part 1. Breeding, Genetic Improvement, and Variety Evaluation

Winter Wheat Breeding, Genetics and Cytology

S.S.JONES, S.R. LYON, K.A. BALOW, M.A. GOLLNICK, K.M. MURPHY, J.C. DAWSON, J. MATANGUIHAN, M. MEDINA, L.A. HOAGLAND, AND J. MORAN, DEPT. OF CROP AND SOIL SCIENCES, WSU

WA007973 was approved for breeder seed increase (Pre-release) in the fall of 2006 and will be named 'Xerpha'. Xerpha is named in honor of the late Xerpha Gaines, WSU botanist and weed specialist. Xerpha is a soft white winter (SWW) wheat with excellent yield stability across all rainfall zones (2006 WSU Variety Testing (VT) data) and has excellent disease resistance, winter hardiness, and quality attributes. It was the highest yielding SWW entry in VT's Soft White Nursery for 2006. This variety should achieve full release in 2008, just 9 years after the initial cross was made. The success and rapid breeding results of Xerpha is a testament to the support of Washington wheat producers, not only for this project, but also for the lab and greenhouse component of the WSU Winter Wheat Breeding Program.

WSU SWW entries in the WSU Extension Uniform Cereal VT Program SWW wheat nursery generally performed extremely well this year. The 2006 VT SWW nursery included 54 entries from 11 different public and private programs. Xerpha was the #1 yielding variety statewide by 2.3 bu/a. The WSU winter wheat program had the #1 variety at 7 of the 18 VT SWW locations in 2006 and also had from three to six entries in the top ten yielding entries at 10 SWW VT locations.

The 2005/06 WSU VT summarized HRW statewide yield results show WA007976 (HRW) was ranked second by only 0.3 bu/a with an average yield of 96 bu/a. Other new WSU HRW breeding lines that performed very well statewide were WA007977 (92 bu/a) and WA008003 (91 bu/a). At five of the seven VT hard winter wheat nurseries, six to seven WSU hard winter wheat entries were among the top 10 yielding lines

Breeding Club Wheat Cultivars for the Pacific Northwest

KIMBERLY GARLAND CAMPBELL[1], CHRIS HOAGLAND[1], LYNN LITTLE[1], LESLEY MURPHY[1], LATHA REDDY[2]
1. USDA-ARS, WHEAT GENETICS, QUALITY, PHYSIOLOGY AND DISEASE RESEARCH UNIT, PULLMAN, WA
2. DEPT. OF CROP AND SOIL SCIENCES, WSU, PULLMAN WA

Cara winter club wheat was developed by the USDA-ARS with assistance from the Washington Agricultural Experiment Station and the Oregon Agricultural Experiment Station. Cara was tested under experimental numbers A97-135 and ARS97-135-9 and approved for released in February of 2007 because of its diverse pedigree, competitive yielding ability, excellent resistance to stripe rust, powdery mildew, common bunt and strawbreaker foot rot and excellent club grain end-use quality compared to the currently grown club wheat cultivars, Bruehl, Chukar, and Coda. The pedigree of Cara is WA7752//WA6581/WA7217. Cara has a height equal to that of Stephens, maturity equal to Coda and earlier than Eltan and Finch, plus yield and test weight that have been comparable to Chukar and Bruehl. New entries in the Washington State soft white variety trials are ARS00235, ARSC96059-1, ARS970059-2, ARS970278-2. ARS00235 and ARSC96059-1 are both tall clubs with high test weight that perform well in dry environments. Both are resistant to stripe rust. ARS00235 has better tolerance to cold than ARSC96059-1. ARSC96059-1 has maturity equal to Tubbs. ARS970059-2 and ARS970278-2 are moderately tall midseason breeding lines suited to higher rainfall environments. We entered six lines into the 2007 Western Regional Soft Winter Wheat Nursery, four clubs and two commons. Dr. R.E. Allan has developed a spring habit derivative of Stephens with excellent stripe rust resistance and maturity equal to Alpowa. That line, ARS05S303, was entered into the Western Uniform Regional Soft Spring Wheat nursery in 2006. Yields were competitive and it has been entered into the Washington Extension Soft Spring Wheat Trial in 2007. Approximately 250 crosses were made to incorporate new sources of resistance to stripe rust into spring and winter breeding lines. We also developed winter and spring wheat populations to study the inheritance of stripe rust resistance. In the breeding program our crosses were to create populations with resistance to barley yellow dwarf virus resistance, cold tolerance, Cephalosporium stripe, Fusarium crown rot and pre-harvest sprouting. We evaluated 5012 yield plots and 33,539 head rows in 10 locations in WA, ID and OR in 2006. In 2007 a yield testing site was added in Farmington.

Identification Of Genes For Cold Tolerance In Winter Wheat

LATHA REDDY[1], PAUL LING[2], MEINAN WANG[2], XIANMING CHEN[2] AND KIMBERLY G CAMPBELL[2]
1. DEPT. OF CROP AND SOIL SCIENCES, WASHINGTON STATE UNIVERSITY, PULLMAN WA
2. USDA-ARS, WHEAT GENETICS, QUALITY, PHYSIOLOGY AND DISEASE RESEARCH UNIT, PULLMAN, WA

Cold temperature is a serious abiotic stress to cereals in areas with severe winters. Two recombinant inbred populations of wheat were assayed for resistance to cold in artificial freezing tests conducted at the WSU Plant Growth Facility. Those populations were also assayed for molecular marker variation. Parents of population 1, Norstar and Centurk78, were screened with 1510 SSR markers and 184 were polymorphic and fit the expected segregation ratio of 1:1. Parents of population 2, Karl and Z0031 were screened with 631 SSR markers. 111 were polymorphic and fit the expected segregation ration of 3:1. Three chromosome regions were associated with cold tolerance in the Norstar/Centurk78 RILs, on chromosome 5A, 5D, and 6b. In the Z0031/Karl population there were chromosome regions associated with cold tolerance, on chromosomes 4B and 5A. The region on chromosome 5AL was identified in both populations. The CBF gene family is hypothesized to play an important role in cold tolerance in cereals and a gene for CBF3 has been identified on chromosome 5A in wheat wild relative *Triticum monocccum* and in barley. We used ortholog sequences of *Tm*CBF (*Triticum monococcum*) and *Hv*CBF (*Hordeum vulgare*) genes and one EST sequence from bread wheat to generate screening primers to isolate full length candidate CBF genes from hexaploid wheat. A hexaploid wheat BAC library constructed in the cultivar 'Avocet-Yr5' was screened with the ortholog markers to isolate CBF gene candidate clones. Two primer pairs were able to efficiently identify BAC clones containing CBF candidate alleles. Selected candidate BAC clones were confirmed and sequenced for full length CBF gene structure analysis. Cloning of CBF ortholog loci from hexaploid wheat will reveal gene structure and sequence information that may be related to cold tolerance in wheat. This knowledge will be utilized for genetic improvement of cold tolerance.

Transferring 'CLEARFIELD' Herbicide Resistance into Washington Winter Wheat Cultivars

HARPINDER S. RANDHAWA AND KULVINDER S. GILL, DEPT. OF CROP AND SOIL SCIENCES, WSU, PULLMAN

Weeds are a serious problem with the winter wheat production in the state of Washington and if uncontrolled, cause significant losses in grain yield and quality. Many of the serious weeds in wheat production are grasses such as jointed goatgrass (JGG), feral rye, Bromus species (downy brome, Japanese brome, cheat), Italian ryegrass, wild oats, and volunteer cereals that are much more difficult to control compared to the broad-leaved weeds. The imidazolinone class of herbicides has very good control over most types of weeds that are problem in winter wheat production but cannot be used because of the presence of AHAS gene. Mutants for the gene (*ahasl-1d* and *ahasl-1b*) have been developed, that can tolerate imidazolinone class of herbicides, and have been used in wheat production. Initially the 'CLEARFIELD' wheat lines were mutant for only one of the three genes that could tolerate only small concentration (35-50 gm/ha) of herbicide. Now a two-gene system of 'CLEARFIELD' wheat is available that can tolerate much higher concentration of herbicide. The mutant genes have not been transferred to winter wheat cultivars from the state of Washington. WSU cultivars such as Eltan and Madsen are very popular in the state of Washington. Therefore, transferring the mutants that make wheat resistant to imidazolinone class of herbicides, to these cultivars would be a valuable alternative for the growers of the state. Using our marker assisted background selection method, we are transferring the two-gene mutations into winter wheat cultivars Eltan and Madsen. By screening over 1700 BC1F1 plants each for Madsen and Eltan with herbicide and then by screening tolerant plants with SSR markers, five plants were selected for each cross to make over 2000 BC2F1. Currently, we are screening these plants with herbicide and selected plants will be screened with SSR markers for background selection.

Improving Spring Wheat Varieties for the Pacific Northwest

K. KIDWELL, G. SHELTON, V. DEMACON AND A. CARTER, DEPT. OF CROP AND SOIL SCIENCES, WSU

In its first year of commercial production, Louise was grown on 15,200 acres, representing 11% of the total soft white spring (SWS) wheat acreage in 2006. Louise replaced all of the Zak acreage, and has the potential to displace a portion of Alpowa acreage in intermediate and high rainfall zones. Louise has superior high-temperature adult-plant (HTAP) resistance to striper rust compared to Alpowa, is partially resistant to the Hessian fly, and has better emergence than both Zak and Alpowa. Grain yields of Louise equaled or exceeded those of Zak, Alpowa and Nick in a majority of the dryland field trials conducted from 2001 to 2006. The end-use quality of Louise is superior to Zak, and this variety is a dramatic end-use quality improvement over Alpowa. Our new SWS line WA8008, which was approved for pre-release in 2007, has many of the same attributes as Louise but is shorter in height, earlier in maturity, and has superior test weight. WA8008 is Hessian fly resistant, has HTAP resistance to stripe rust, has excellent quality, and is targeted for production in the high rainfall zone.

Our hard red spring (HRS) variety Tara 2002 was grown on more than 30,000 acres in 2006. Tara 2002 is early maturing, is resistant to stripe rust and the Hessian fly, and has outstanding end-use quality. Tara 2002 has unique quality characteristics that have provided domestic outlets for progressive farmers in the region, helping develop alternative markets for locally grown grain. Our new line WA7954, which was approved for pre-release in 2007, has many of the requirements of a successful HRS variety in the intermediate to high rainfall zones under direct seeding conditions. WA7954 is Hessian fly resistant, has HTAP resistance to stripe rust, and has excellent bread baking quality. When compared to Tara 2002, WA7954 is later in heading, shorter in height, and has higher test weight with significantly higher grain protein content.

WSU Wheat Quality Program and Research on End-Use Quality of Wheat

B.-K. BAIK AND T. HARRIS, DEPT. OF CROP AND SOIL SCIENCES, WSU

We provide end-use quality testing of breeding lines for the spring and winter wheat breeding programs at Washington State University. For the 2006 harvest, we tested 1,147 breeding lines for grain quality, milling quality, composition, biochemical properties and baking quality. The test results were analyzed and provided to the wheat breeders for screening breeding lines. The end-use quality assessment of wheat breeding lines facilitates the release of new varieties with improved marketability in addition to good agronomics.

To identify optimum agro-climatic zones for the production of wheat with desirable protein content, we estimated grain protein content potential of each growing location in Washington State. We collected the protein content data of multiple varieties in each of seven different wheat classes grown in 9-20 locations in the state for five to six years. The data were used to develop a guideline and draw a map for selecting agro-climatic zones for the production of each class of wheat with desirable protein content. By identifying optimum agro-climatic zones for the production of wheat with desirable protein content, we will be able to improve our capacity to consistently produce and deliver wheat of improved end-use quality to domestic and international markets.

We explored the role of ash on the processing properties of wheat flour dough and product quality. The results suggested that the minerals interact with the flour components possibly through ionic interactions and affect the pasting properties of wheat flour. We also studied the functional properties of protein required for making noodles with the goal of developing better noodle wheat genotypes. To identify the protein quality profile suitable for making noodles, we determined protein quality of wheat flour, noodle dough and dough sheets. Protein quality of white salted noodle flours appears to be intermediate between typical hard and soft wheat varieties. This will eventually benefit wheat growers by expanding overseas wheat export in noodle wheat markets.

Forward Breeding Approach for Improving PNW Wheats using Marker-assisted Selection

HARPINDER S. RANDHAWA AND KULVINDER S. GILL, DEPT. OF CROP AND SOIL SCIENCES, WSU, PULLMAN

Wheat cultivars grown in PNW face continuous production threats from various biotic and abiotic stresses. Among the various biotic stresses, stripe rust causes major challenge for both spring and winter wheats. The resistance of a cultivar to stripe rust may become ineffective with appearance of new races due to changes in ever-evolving populations caused by mutations, population shifts, or migration. To overcome these challenges new source of resistance need to be identified and deployed periodically. Yield and quality penalties are inevitable by introgression of new resistance genes, which are often present in unadaptive donor source. We have used maker assisted background selection against the donor parent to reduce the chromosomal regions harboring the unwanted 'bad genes'. We have exploited the potential of marker assisted background selection in designing the forward breeding strategies to further improving upon the wheat cultivars by increasing the superior gene combination along with the required trait (stripe rust resistance) from the donor parent. In this project, based on the screening of 150 lines using over 250 SSR markers 32 forward breeding lines were planted as plot in field 2006. Data for plant height, disease resistance, lodging and shattering resistance, heading date, leaf color, PLS have been recorded. Top five lines based on the plot yield data were evaluated for quality, which are being tested in State Soft white wheat nursery in 2007. Another 51 lines were selected based on disease resistance and other agronomic traits based on the head rows in 2006. All these lines are being evaluated in the field plot during the summer of 2007. Based on the preliminary results, our marker based forward breeding approach will make wheat breeding more efficient and cost effective, which in turn will allow wheat growers in the PNW to maintain their competitive edge in the international markets.

Wheat Applied Genomics: Marker-assisted Selection for Improved Disease Resistance and End Use Quality in Pacific Northwest Wheat

ARRON CARTER[1], DEVEN R. SEE[2], KIMBERLEE KIDWELL[1], KIMBERLY GARLAND CAMPBELL[2]
1. DEPT. OF CROP AND SOIL SCIENCES, WASHINGTON STATE UNIVERSITY, PULLMAN WA
2. USDA-ARS, WHEAT GENETICS, QUALITY, PHYSIOLOGY AND DISEASE RESEARCH UNIT, PULLMAN, WA

The WheatCAP Coordinated Agricultural Project for Wheat is a multi-state, multi-institution project, funded by USDA/CSREES dedicated to the genetic improvement of US wheat through research, education and extension. A primary goal is to implement marker assisted selection (MAS) in more than 25 public wheat breeding programs. U.S. wheat researchers have developed protocols for more than fifty molecular markers for resistance genes and quality traits and have used these markers to incorporate valuable genes in the best breeding lines from ten different market classes. These lines will be used in this project to deploy the targeted genes into thousands of lines across the breeding programs using high-throughput forward breeding strategies. This will be possible by the incorporation in this project of the four high-throughput genotyping laboratories recently established by USDA. In 2006, the USDA-ARS Small Grains Genotyping Laboratory provided a total of 18812 molecular data points to Wheat CAP collaborators Jorge Dubcovsky (CA), Ed Souza and Bob Zemetra (ID), Luther Talbert, Phil Bruckner and Mike Giroux (MT), Oscar Riera-Lizarazu and Jim Peterson (OR), and Kim Kidwell and Kim Campbell (WA) as well as to barley researcher Pat Hayes (OR). In Washington, the spring and USDA wheat breeding programs are introgressing genes for resistance to stripe rust, barley yellow dwarf virus resistance, resistance to Fusarium crown rot, and for high grain protein content. In addition we created a population of 188 lines from the Louise/Penewawa and identified 365 polymorphic markers on the two parents. The progeny will be planted at Spillman and Kambitsch (Univ of Idaho) farms in 2007 and assayed for stripe rust resistance, heading date, end use quality, yield, and agronomic traits. The purpose of this research is to identify molecular markers for complex traits for use in PNW wheat breeding programs. The use of molecular markers in wheat breeding will speed up the incorporation of important genes and the development of new wheat cultivars.

Application of Biotechnology to Spring Wheat Variety Improvement

D. SANTRA, M. SANTRA, V. DEMACON, G. SHELTON, A. CARTER AND K. KIDWELL, DEPT. OF CROP AND SOIL SCIENCES, WASHINGTON STATE UNIVERSITY

Biotechnology is useful for identifying superior breeding lines in early generations of selection that carry genes that are deemed as being essential for commercial success prior to field evaluation. Our goal is to use marker-assisted selection (MAS) to introgress target gene(s) into adapted germplasm as quickly as possible. We used this strategy to incorporated *Yr5* and *Yr15,* two seedling resistance genes to stripe rust that have not been circumvented by any race of the pathogen found in North America to date, into Scarlet (HRS), WA7900 (HWS), Zak (SWS) and Alpowa (SWS). One Zak, two Scarlet and one WA7900 backcross derived-line were confirmed to carry both *Yr*5 and *Yr*15 in the homozygous state. These lines are promising candidates for variety release since they are expected to have durable resistance to stripe rust. These lines will be evaluated in 2007 variety testing trials. A high grain protein content gene, *Gpc*-B1, was incorporated into Scarlet, Tara 2002, and the hard red winter line WA7869 using MAS. WA7975, a backcross derivative of WA7869 with *Gpc*-B1, was approved for pre-release in 2007. WA7975 is a tall, late maturing variety targeted to the semi-arid region that has high grain yield potential, excellent bread baking quality, and carries the stripe rust resistance gene *Yr*36. MAS also was used to incorporate two novel Hessian fly resistance genes, *H9* and *H13*, into adapted spring wheat germplasm and yield trials of this material will begin in 2007. We also successfully introgressed the 2+12 glutenin profile and HTAP into an Eden (spring club) background, and early generation material will be evaluated in the field in 2007. Genetic linkage mapping efforts, including the use of mircrospore culture for population development, have progressed for resistance genes associated with Rhizoctonia and Pythium root rots.

Utilizing Doubled Haploids as a Tool to Increase the Efficiency and Effectiveness of a Wheat Breeding Program

P.E. REISENAUER H.S. RANDHAWA, AND K.S. GILL, DEPT. OF CROP AND SOIL SCIENCES, WSU

Double haploids allow wheat breeders to achieve homozygosity from early generation breeding material. The procedure eliminates growing several generations of selfing, which is normally required before uniform lines can be selected to be evaluated in yield trials. There are several steps in doubled haploid production. To induce homozygosity, wheat (female) x maize (male) are crossed. After fertilization of the egg by the male gametes, the complete genome of the pollinator (corn) is rapidly eliminated during the first few days of embryo development. Since the endosperm gradually degenerates, applying plant growth regulators (2,4-D) to florets or by injection into the top node one day after pollination prolongs seed longevity. The resultant haploid embryos are rescued aseptically to a defined medium, usually about 14-16 days after pollination and before the complete breakdown of the caryopsis. Haploid plantlets are then regenerated on the sterile medium in a growth chamber. The plantlets are transplanted into sand filled pots after they reach the 3 leaf stage. Once the plantlets have developed 2-3 shoots they are removed from the sand. The roots are then washed with an aqueous colchicine solution to induce homozygous, doubled haploid plants – think of it as making a "photocopy" of the chromosome. The photocopy is genetically identical to the original, resulting in a true breeding line. Microspore culture, requiring sophisticated laboratory techniques and equipment, is an alternative method to achieve haploid plants. Haploid cells (n) are treated chemically to induce doubling of the chromosomes thereby producing doubled haploid (2n) plants. Utilizing this method, there is potential to produce several hundred plants from a single anther. No matter which technique is employed, there is still a need to select among the doubled haploid populations for individuals carrying desirable genetic constitutions. We have optimized a method to produce double haploid plants using wheat-corn hybridization approach.

Identification of Chromosome Regions Associated with Resistance to Crown Rot and Pythium Root Rot in a 'Sunco' X 'Macon' Spring Wheat Population

GRANT POOLE[1], RICHARD SMILEY[2], TIM PAULITZ[3], KIM KIDWELL[1] AND KIM GARLAND CAMPBELL[4].
1. DEPT. OF CROP AND SOIL SCIENCES, WASHINGTON STATE UNIVERSITY, PULLMAN WA
2. DEPT. OF BOTANY AND PLANT PATHOLOGY, OREGON STATE UNIVERSTIY, COLUMBIA BASIN AGRICULTURAL RESEARCH CENTER, PENDLETON OR
3. USDA-ARS, ROOT DISEASE RESEARCH UNIT, PULLMAN, WA
4. USDA-ARS, WHEAT GENETICS, QUALITY, PHYSIOLOGY AND DISEASE RESEARCH UNIT, PULLMAN, WA

Crown rot, caused by a complex of *Fusarium* species including *F. pseudograminearum* and *F. culmorum*, can reduce wheat yields by greater than 50%. Pythium root rot, caused by *P. debaryanum* and *P. ultimum* can reduce wheat yield by as much as 25%. Both are important diseases in Pacific Northwest Wheat Cropping systems. Partial resistance to crown rot has been documented in wheat and a total of 9 QTLs have been identified on 6 different chromosomes (1A, 1D, 2B, 2D, 4B, and 5D) in Australian spring wheat. No QTLs have been identified for Pythium root rot resistance in wheat. A recombinant inbred population of 'Sunco' (an Australian Spring wheat with tolerance to both crown rot and to Pythium root rot) by 'Macon', a PNW hard white wheat that is susceptible to both diseases, was developed. 294 polymorphic SSR markers have been identified between Sunco and Macon. Those polymorphic markers will be used to construct a genetic linkage map for the Sunco-Macon population. Progeny from the population will be assayed using disease screening methods conducted in the WSU Plant Growth Facility. For Fusarium crown rot, seedlings will be germinated in conetainers and the conetainer then inoculated with isolates of *F. pseudograminearum* cultured on millet seed. For Pythium, two techniques will be evaluated. Wheat seedlings will be grown hydroponically. When seedlings are 7 days old, the hydroponic solution will be inoculated with isolates of the zoospore producing species, *P. aphanidermatum.* The other method will use cultures of *P. ultimum* to inoculate seedlings in conetainers. For both diseases, plant height, root growth, and plant biomass will be rated on a periodic basis for up to 45 days after inoculation. The entire population will be evaluated for each disease using three replications. Data will be used to identify regions of chromosomes that are associated with disease resistance for marker assisted selection for both diseases.

Biotechnology and Barley Improvement

S.E. ULLRICH, V.A. JITKOV, J.S. COCHRAN, I.A. DEL BLANCO, AND H.-J. LEE, DEPT. OF CROP AND SOIL SCIENCES, WSU
COLLABORATORS: A. KLEINHOFS, D. VON WETTSTEIN, J.W. BURNS, X. CHEN, T.C. PAULITZ, AND B.-K. BAIK WITH RESEARCH ASSOCIATES, TECHNICIANS AND/OR GRADUATE STUDENTS

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 novel molecular methods is used to solve barley genetics puzzles and to breed improved cultivars. The two most recent WSU releases are products of mutation breeding. 'Bob' is from an A-308 x 'Baronesse' cross. A-308 is a somaclonal mutant in 'Lewis' selected after *in vitro* culture. 'Radiant' is from a sodium azide-induced proanthocyanidin-free (lacks a type of polyphenol) mutant in 'Harrington' x Baronesse cross. Based on results through 2006 from across eastern Washington, Bob (97 loc-yr), and Radiant (93 loc.-yr) yielded 97 and 98% of Baronesse, respectively. Three conventionally bred two-row lines (02WNZ1095, 02WNZ1095, 02WNZ100) are release candidates yielding 99-101% of Baronesse (22 loc-yr). A new hulless waxy line, WA9820-98, is a release candidate to be directed at food and feed use. Novel trait combinations bred include hulless + waxy + proant-free for food products and hulled + waxy for grain fractionation and ethanol production. U.S. Barley Genome Project research involves molecular genetic mapping of dormancy, preharvest sprouting, 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 pest resistance is underway. New breeding lines have been identified with resistance to barley stripe rust, Russian wheat aphid, and Hessian fly.

Marker-assisted Selection for High Grain Yield and Quality in Premium Malting Barley Germplasm

ISABEL ALICIA DEL BLANCO, DERIC A. SCHMIERER, ANDRIS KLEINHOFS AND STEVEN E. ULLRICH, DEPT. OF CROP AND SOIL SCIENCES, WSU

Conventional breeding has not produced high-yielding premium malting barleys competitive in production to the best barley-for-feed cultivars well adapted to the diverse conditions of the Pacific Northwest (PNW). Baronesse is the leading feed barley cultivar in the PNW. Our objective is to transfer Baronesse yield and adaptation to high malting quality barley cultivars while maintaining their premium malting quality. Inbred lines derived from crosses between Baronesse and high quality malting barley cultivars were previously selected by targeting Baronesse derived putative yield QTLs on chromosomes 2(2H) and 3(3H). Our next objective was to advance germplasm that maintains the premium malting quality of the recurrent parent while improving the yield and adaptability of these lines. For that objective we targeted yield QTL regions on chromosomes 2(2H) and 3(3H) and the telomeric region on the long arm of chromosome 7(5H), which has been consistently reported as a carrier of QTLs for several quality traits such as malt extract, alpha amylase activity, diastasic power and free amino acid nitrogen, as well as for controlling seed dormancy and pre-harvest sprouting. We developed PCR-based markers from previously identified RFLP probes that map to the chromosome 7(5H) QTL region. These PCR-based, user-friendly, markers allowed us to screen a large number of recombinant lines. The selected lines carrying different combinations of grain-yield QTLs will be tested in replicated trials, with standard size plots, at two locations during the field season 2007. The two locations are dry-land Pullman, WA and irrigated Aberdeen, ID. These experiments will allow us to identify the higher yielding lines that maintain the premium malting quality, and to estimate the contribution of the different QTLs in grain yield.

Genetic Analysis of Preharvest Sprouting in a 2-Row Barley Cross

H. LEE, I.A. DEL BLANCO, J.A. CLANCY, AND S.E. ULLRICH, DEPT. OF CROP AND SOIL SCIENCES, WSU

Preharvest sprouting (PHS) can be a problem in barley production, especially of malting barley. Rain or high humidity from near physiological maturity (PM) onward can cause sprouting in spikes. This has serious consequences for malting of grain, since rapid and complete germination is critical. Much research has focused on genetic control of dormancy (measured as percent germination) in barley. The objective of this study was to determine if the QTLs (genes) discovered in previous research of dormancy in the U.S. Bartley Genome Project mapping population in the 2-row barley cross 'Harrington'/TR306 (H/TR) can be related to the genetic control of PHS. PHS was measured as 'sprout score' (SSc) based on visual sprouting in mist chamber-treated spikes at 0 and 14 d after PM and as 'alpha-amylase activity' (AA) in kernels taken from mist chamber-treated spikes that showed little or no visible sprouting at 0 and 14 d after PM. Dormancy measured as germination percentage was also evaluated at 0 and 14 days after PM. QTLs for dormancy were previously mapped to chromosomes 5L and near the 7L telomere. Interval mapping of the H/TR population grown in two environments (greenhouse and field) for SSc revealed QTLs on chromosomes 1, 2, 3, and 7 and for AA on chromosomes 1, 3 and 7. The two dormancy QTLs previously identified on chromosomes 5 and 7 were confirmed in this study, and QTLs on chromosomes 1 and 2 were newly identified. Some of the PHS QTLs coincide with known dormancy QTLs, but some do not. Some of the PHS and dormancy QTLs identified here coincide with PHS and dormancy QTLs identified from other crosses. This study complements a previous PHS in the 6-row Steptoe/Morex mapping population. QTLs identified should aid breeding efforts for balance between preharvest sprouting and dormancy in barley and other cereals.

WSU Extension Uniform Cereal Variety Testing Program – 2006

J. BURNS, J. KUEHNER, DEPT. OF CROP AND SOIL SCIENCES, WSU

The goal of the WSU Extension Uniform Cereal Variety Testing Program is to provide a uniform replicated testing program that provides comprehensive, objective and readily available information on the performance of public and private cereal varieties to Washington growers. The program also provides WSU cereal breeders and other public and private breeders with the same type of information for screening advanced lines entered in the program trials. The diversity of growing regions characteristic of Eastern Washington for wheat and barley production necessitates using a large number of testing locations. In addition, multiple market classes of wheat grown commercially and both feed and malting barley require unique testing locations. The Variety Testing Program established 101 separate nurseries across 13 eastern Washington counties in 2006. A combined total of 183 wheat and barley varieties/experimental lines were evaluated (83 winter wheat, 10 winter barley, 50 spring wheat and 40 spring barley). Components of the Variety Testing Program that enhanced value to producers and plant breeders were: (1) harvest data for winter wheat was provided within 2-days after harvest on both an e-mail server list as well as the Variety Testing Program web site: http://variety.wsu.edu. Spring data was provided within three weeks of harvest, (2) over 5000 sub-samples from variety testing winter and spring wheat nurseries were utilized for Genotype by Environment wheat quality evaluations by USDA and WSU cereal chemists. This data source is a cornerstone in developing the *Preferred Wheat Varieties for Washington Based on End-use Quality* publication, (3) formal agreements in place with the Federal Grain Inspection Service provided market class grade evaluations of 1030 new lines of winter and spring wheat entered in the Variety Testing Program and (4) twenty-three nursery tours/field days were held in cooperation with local WSU Extension Educators and commodity groups with a total attendance of 970 individuals.

Barley Mutant Paves Way for Barley and Wheat Acceptable to Celiac Patients

DITER VON WETTSTEIN, NII ANKRAH, BRIAN GREEN, TYSON KOEPKE, PATRICK REISENAUER, DEPT. OF CROP AND SOIL SCIENCES, WSU

In the State of Washington are ~42,000 celiac sprue patients. They live with total abstinence from wheat, barley, rye containing food. Their painful erasure of the brushborder in the small intestine is caused by stretches (epitopes) in grain storage proteins that cannot be digested by stomach, pancreatic and intestinal enzymes and cause the autoimmune destruction of the brushborder. The celiac causing epitopes are located in the barley B, C and γ hordeins of barley, and in the gliadins of wheat. All these proteins are highly similar in their primary structure. The lys3a mutant in barley cannot synthesize B, C and γ hordeins. The mutation prevents the transcription of the corresponding genes. It is in an enzyme that has to remove methyl groups from the DNA before these genes can be transcribed in the endosperm into messenger RNA for translation into protein. Lys3a mutant variety Piggy is healthier for pigs due to absence of these lysine poor hordeins. But D-hordein is synthesized in the mutant because its gene is never methylated. D-hordein is 90 % identical to wheat High Molecular Weight glutenin, that alone determines baking quality. Informatics tells that the six wheat genes for HMW glutenins are unmethylated while the gliadin genes are methylated. We are therefore looking for lys3a type mutants in wheat to get rid of all the gliadins. The breads shown in Fig.1b to g were baked from flour lacking all gliadins but with an addition of purified High Molecular Weight glutenin produced in fermenters by yeast containing the wheat genes. The dough had outstanding elasticity. Techniques for breeding wheat and barley suitable for celiac patients will be demonstrated.

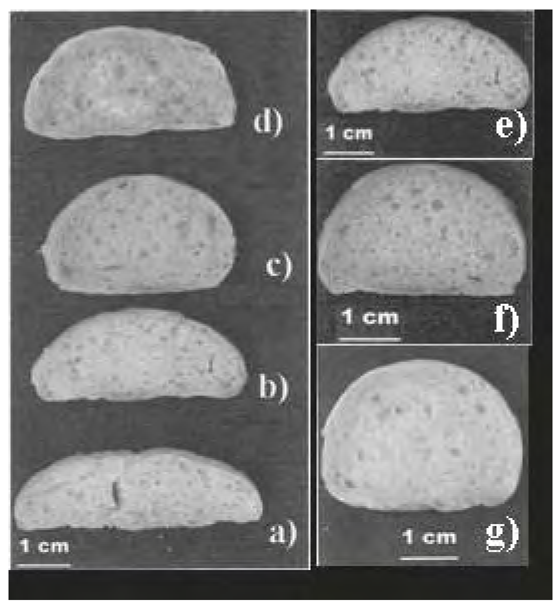

Fig. 1. b-g: bread baked with highly elastic dough lacking gliadins and containing only wheat High Molecular Glutenins (I. Bauer, 2005)

Grain Legume Breeding and Genetics

K.E. MCPHEE, W. CHEN, J. PFAFF, L. BURNS AND S.L. MCGREW, USDA-ARS, GRAIN LEGUME GENETICS AND PHYSIOLOGY RESEARCH UNIT, PULLMAN, WA

The grain legume breeding program is focused on producing new improved cultivars of dry pea, lentil, chickpea and fall-sown winter-hardy pea and lentil. All types of edible grain legumes must be environmentally adapted, high yielding and market acceptable. The goal of the dry pea breeding program is to develop improved cultivars of green and yellow cotyledon spring and winter peas as well as marrowfat types adapted to all suitable US production regions. Two new dry pea varieties were approved for release in 2006, '**Medora**', an upright green pea, and '**Windham**', a semi-dwarf winter feed pea. '**Specter**' was released in 2005 and was the first white-flowered, clear-seeded winter feed pea cultivar to be released from the USDA-ARS program.

The U.S. lentil industry competes in the world market and must have cultivars with acceptable quality for a variety of market classes. '**Pennell**' and '**Merrit**', both large-seeded, yellow cotyledon lentils were released to the industry and have good standing ability and higher yields when compared to Brewer. '**Riveland**', the most recently released lentil cultivar, a large green, yellow cotyledon type, has performed well in field trials and was approved for release in 2006. Two selections of zero-tannin lentils, LC7601114YZ (yellow cotyledon) and LC00600917RZ (red cotyledon) were approved for release in 2007 and provide additional opportunities for producers to service niche canning markets.

Several chickpea cultivars resistant to Ascochyta blight have been released. '**Sierra**' was released with greater resistance to Ascochyta blight, larger seeds and improved yields and quality. '**Dylan**', a Café type chickpea with fern leaf morphology and improved blight resistance, was released in 2005. '**Troy**', a large-seeded Spanish White type chickpea with fern leaf morphology and improved resistance to Ascochyta blight, was approved for release in 2006.

For more information, please refer to the Grain Legume Research Unit website at: http://pwa.ars.usda.gov/pullman/glgp/.

2006 Dry Bean Performance Evaluation in Washington

AN. M. HANG, DEPT. OF CROP AND SOIL SCIENCES, WSU IRRIGATED AGRICULTURAL RESEARCH AND EXTENSION CENTER, PROSSER, WA

The WSU Irrigated Agricultural Research and Extension Center continues to coordinate the National Cooperative Dry Bean Nursery Program as part of the W1150 multi state project: 'Exotic Germplasm Conversion and Breeding Common Bean (Phaseolus vulgaris L.) for Resistance to Abiotic and Biotic Stresses and to Enhance Nutritional Value'. In 2006 , there were 30 entries of all market classes (black, navy, great northern, pink small red, pinto light red kidney and cranberry). The nursery was planted on Shano silt loam soil at Othello Research Farm, WSU on May 26. Fertilizers were adjusted to 100 lbs N and 80 lbs P per acre. Eptam (2 qt/a) and Sonalan (1 qt/a) were preplant incorporated into the top 4 inches to control weed. Plots were free of weed, and seedling vigor was very good. All lines were grown well until high temperatures during July (95 to 100 F during seed feeling stage) did reduce yield of great northern and pinto significantly. Days to bloom was from 40 d (kidney lines) to 46 days for black and navy. Days to maturity varied from 93 to 111 days. No insects or diseases were observed in 2006. Ten plants of each plots were cut at the ground level for harvest index and biomass yield determination. High temperature during July did decrease bean yield of all lines except the early maturing lines (kidney). Yield varied from 1978 lbs (cv. Capri) to 3808 lb/a (6 I 15 pinto line from UI). Seed moisture was from 7 to 8% at harvest. Overall yield of 2006 growing season was 2972 lbs/a and about 680 lb/a less than in 2005.

More information: http://www. prosser.wsu.edu/pdf%20files/2006cdbnreport.pdf

Part 2. Pathology and Entomology

Control of Stripe Rusts of Wheat and Barley

X.M. CHEN, D.A. WOOD, L. PENMAN, F. LIN, YUMEI LIU, M.N. WANG, J. ZHAO, T. CORAM, AND K. RICHARDSON. USDA-ARS WHEAT GENETICS, QUALITY, PHYSIOLOGY, AND DISEASE RESEARCH UNIT AND DEPT. OF PLANT PATHOLOGY, WSU

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Rusts of wheat and barley were monitored throughout the Pacific Northwest (PNW) using trap plots and through field surveys during the 2006 growing season. Through collaborators in other states, stripe rusts of wheat and barley were monitored throughout the US. In 2006, wheat stripe rust occurred in more than 20 states, but the disease was generally much less than in 2005 due to the weather conditions unfavorable to stripe rust. However, the disease caused 15% yield losses in California and up to 28% yield losses on susceptible winter and spring wheat cultivars in our experimental plots. Barley stripe rust occurred in Arizona, California, Idaho, Oregon, and Washington, but the damage was low. Leaf rust and stem rust were either light or absent in the PNW. A total of 18 wheat stripe rust races and 11 barley stripe rust races were identified, of which five wheat stripe rust and two barley stripe rust races were new. In 2006, we evaluated more than 16,000 wheat and 5,000 barley entries for resistance to stripe rust and other diseases. We have mapped four genes in wheat and one gene in barley for durable high-temperature, adult-plant resistance and four genes in wheat and two genes in barley for race-specific all-stage resistance to stripe rust. We identified genes regulated by the *Yr5* resistance using the microarray technique. To study functional genomics of the stripe rust and further characterize stripe rust populations, we have constructed the first bacterial artificial chromosome (BAC) library and full-length cDNA library for the wheat stripe rust pathogen. From the 196 cDNA clones sequenced, we identified 51 different genes with functions in the fungal growth, defense, and virulence/infection. In 2006, we evaluated nine foliar fungicide treatments and eight seed treatments for control of stripe rust. Better chemicals, formulations, and application schedules were identified.

Geographic Distribution of *Rhizoctonia* and *Pythium* Species in Soils from Dryland Cereal Cropping Systems in Eastern Washington

KURTIS L. SCHROEDER, PATRICIA A. OKUBARA, AND TIMOTHY C. PAULITZ, USDA-ARS, ROOT DISEASE & BIOLOGICAL CONTROL RESEARCH UNIT, PULLMAN, WA

Rhizoctonia and *Pythium* species cause substantial reductions in yield in eastern Washington. Both pathogens are common in agricultural soils; however, the specific species or anastomosis group (AG) present can vary from site to site. Due to a wide range in virulence among these different groups, the impact of these pathogens could vary greatly depending on the species composition within a particular field. In the spring of 2006, soils were collected from 21 wheat variety testing sites and 29 grower fields throughout eastern Washington. DNA was extracted from these soils using a commercial kit in combination with pressure cycling treatment. Specific primers were used in conjunction with real-time PCR to detect and quantify *R. solani* AG-8 and AG-2-1, *R. oryzae*, *P. irregulare* groups I and IV, and *P. ultimum*. *Rhizoctonia solani* AG-8 was found most frequently in areas of low rainfall (<350 mm/year) while *R. oryzae* and *P. irregulare* groups I and IV were prevalent in higher rainfall zones (>350 mm/year). *Pythium irregulare* group IV was also generally more abundant in rotations with legumes. The presence of *P. ultimum* was sporadic and occurred only in the higher rainfall zone or irrigated plots. *Rhizoctonia solani* AG-2-1 was primarily found in fields with a history of mustard or canola cultivation, although this pathogen was also detected at a couple of locations with no history of Brassica production. The use of these robust tools for detection and quantification of soilborne pathogens can greatly improve our understanding of the diversity of these organisms in the soil. The next step will be to use this information to correlate pathogen loads in the soil with yield, and eventually to develop a tool to estimate the potential impact of these soilborne diseases before planting.

Grain Legume Pathology

W. CHEN AND K.E. MCPHEE, USDA-ARSGRAIN LEGUME GENETIC AND PHYSIOLOGY RESEARCH UNIT, PULLMAN, WA

Grain legumes (dry peas, chickpeas and lentils) are important rotational crops in cereal-based production systems. Diseases of grain legumes have been a major constraint to the yield and quality, and consequently to the profitability of grain legume production. Our research program is focusing on several important diseases of grain legumes. Our recent research results are summarized here.

Ascochyta blight of chickpea: Management of chickpea blight (*Ascochyta rabiei*) is mainly through use of resistant cultivars and judicious application of fungicides. The pathogen population can be divided into two pathotypes. Chickpea genotypes with resistance to pathotype II are identified and being used for resistance breeding. Fungicide trails showed that Headline and Quadris are effective in reducing disease severity. The new fungicides Proline and Quadris opti are also very effective. Quadris opti is a new formulation combining Quadris and Bravo, whereas Proline presents a new chemistry in fighting against Ascochyta blight, and provides an alternative fungicides in managing fungicide resistance. Applications of these fungicides increased yield significantly on susceptible cultivars and on moderately resistant cultivars under high disease pressure.

White mold of lentils and peas: White mold caused by *Sclerotinia sclerotiorum*, *S. minor* or *S. trifoliorum* can be a serious disease under conditions conducive to the disease (cold and moist weather, and excessive vegetative growth). Several lines of lentils and peas showed tolerance to the disease. Mapping populations have been developed using these tolerance sources and are used to identify tolerance genes or quantitative trait loci that will help resistance breeding. The pathogen populations in lentil fields near Colton and Spangle were extensively sampled and studied for genetic variation through mycelial compatibility grouping and microsatellite loci. Considerable genetic variation was found in the pathogen populations, which has been taken into consideration in developing screening procedures in breeding programs.

More information and our last year's progress report can be found at: http://pwa.ars.usda.gov/pullman/glgp/.

Establishing Cereal Leaf Beetle Biocontrols in Washington State

DIANA ROBERTS (WSU EXTENSION, SPOKANE), TERRY MILLER (NORTHWEST BIOLOGICAL CONTROL INSECTARY/QUARANTINE [NWBIQ], PULLMAN), KEITH PIKE (WSU ENTOMOLOGY, PROSSER), STEVE MILLER (USDA-APHIS, SPOKANE)

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By 2006 the cereal leaf beetle (*Oulema melanopus)* had spread into 17 counties, primarily in eastern Washington. It has a wide host range in the grass family and may cause yield losses up to 75% in spring wheat. Introduced biocontrol species have kept cereal leaf beetle (CLB) at subeconomic levels in midwestern and eastern states.

The 2 primary biocontrol species are *Tetrastichus julis* (larval parasitoid) and *Anaphes flavipes* (egg parasitoid). Both are tiny wasps that are specific to CLB. They do not harm humans, animals, or plants.

Farmer cooperators, whose fields had high infestations of CLB, have maintained field insectaries where we release the parasitoids. The larval parasitoid has survived and multiplied extremely successfully. After the 2006 season we discontinued 3 field insectaries as the wasp had reduced CLB populations to very low levels within them. We have also found this wasp traveling on its own into farm fields at least 40 miles from the nearest insectary.

Farmers in the wetter, dryland areas of the state may never need to spray for CLB as the larval parasitoid is establishing in these areas along with the pest. Farmers who have irrigated cereals, especially in the Columbia Basin, may need to withstand some yield loss while the parasitoids increase to where they can maintain CLB at subeconomic populations. Currently labeled insecticides will kill both the parasitoids and CLB. We are testing softer, more specific chemicals.

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

Part 3. Agronomics, Alternate Crops and Systems

Fifty Years of Predicting Wheat Nitrogen Requirements Based on Soil Water, Yield, Protein and Nitrogen Efficiencies

WILLIAM PAN[1], WILLIAM SCHILLINGER[1], DAVID HUGGINS[2], RICHARD KOENIG[1] AND JOHN BURNS[1]
[1] DEPT. OF CROP AND SOIL SCIENCES, WSU
[2] USDA-ARS LAND MANAGEMENT AND WATER CONSERVATION RESEARCH UNIT, PULLMAN, WA

Washington State University has been a recognized leader in the development of soil and climate based N recommendation modelling. During the early 1950's synthetic N fertilizers were gaining widespread adoption in the wheat growing region of the inland Northwestern U.S. WSU agronomists quickly recognized water and N as the two principal determinants of grain yield and quality (Jacquot, 1953). Numerous N fertility trials across a range of climatic environments, soils and cropping systems provided the initial data for estimating wheat yield potentials based on predicted precipitation and root zone soil moisture. Nitrogen fertilizer recommendations were made from yield-based crop N requirements, estimates of soil N supplies and N use efficiencies. Leggett's (1959) N recommendation model, based on the regional variations in yield-water relationships and crop-soil N budgets, has stood the test of time for nearly 50 years, as confirmed by recent N fertility and agronomic trials (Engle et al., 1975; Mahler, 2004; Koenig, 2005). A recent data analysis of yield-water relationships reveals a remarkably similar slope but different y-intercept defining the lowest available water levels at which grain yields are obtainable (Schillinger, 2006). Spring soil moisture remains a reasonable yield predictor in this Mediterranean climate, but variable in-season rainfall is still a major source of error. Adjustments in the N recommendation model have been made to accommodate differences in wheat class, soil characteristics, management practices and climatic factors that affect water and N use efficiencies (Fig. 1). However, our ability to extrapolate the regional model to site-specific applications has been restricted by the inability to predict landscape-scale processes that control water redistribution, water-yield and yield-nitrogen use relationships that define the unit N requirement. The generalized 50% single season N uptake efficiency used in the model is not likely to occur consistently within a given field or from year-to-year and is currently under increased scrutiny in order to realize improvements in field-scale N management and N uptake efficiencies.

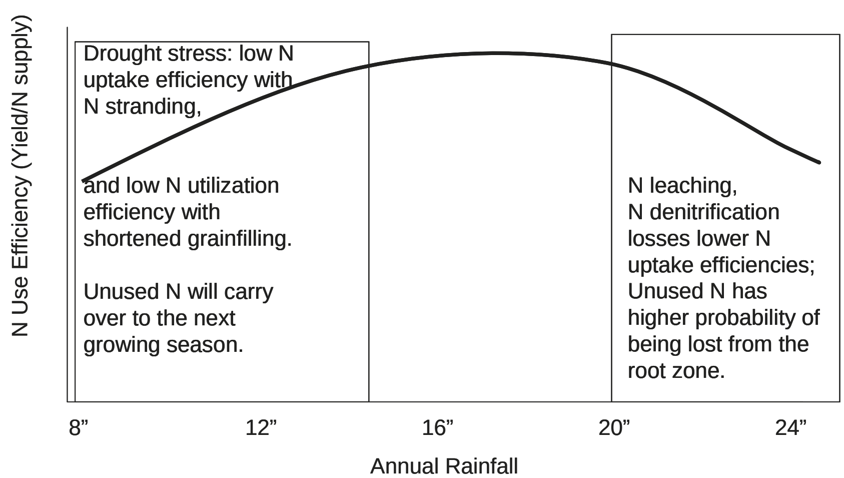


Figure. 1. Relationship between N use efficiency and rainfall zones across eastern Washington.

Ten Years of Annual No-Till Cropping Research near Ritzville

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

Overview. We have completed year 10 of an ongoing large-scale (20 acre) multidisciplinary no-till and minimum-till cropping systems study on the Ron Jirava farm near Ritzville, WA. Soft white and hard white classes of winter and spring wheat, spring barley, yellow mustard, and safflower have been grown in various rotation combinations. Annual precipitation was less than the long-term average in 8 out of 10 years. Rhizoctonia bare patch disease caused by the fungus *Rhizoctonia solani* AG-8 appeared in year 3 and continued through year 10 in all no-till plots. All crops were susceptible to rhizoctonia, but bare patch area in wheat was reduced, and grain yield increased, when wheat was grown in rotation with barley every other year. Remnant downy brome weed seeds remained dormant for 6 years and longer to heavily infest recrop winter wheat. There were few quantifiable changes in soil quality due to crop rotation, but soil organic carbon increased in the surface 0-to 5-cm depth with no-till during the 10 years to approach that found in undisturbed native soil. Annual no-till crop rotations experienced lower average profitability and greater income variability compared to WW-SF. Yellow mustard and safflower were not economically viable. Continuous annual cropping using no-till provides excellent protection against wind erosion and shows potential to increase soil quality, but the practice involves high economic risk compared to winter wheat – summer fallow. The ability of spring-planted crops to compete economically with winter wheat - summer fallow is highly dependent on the quantity of precipitation stored in the soil over the winter and the quantity of rainfall in May and June. Figure 1 shows the grain yield performance of continuous annual no-till soft white spring wheat compared to winter wheat – summer fallow (i.e., one crop every two years) at the Jirava site over the past ten years.

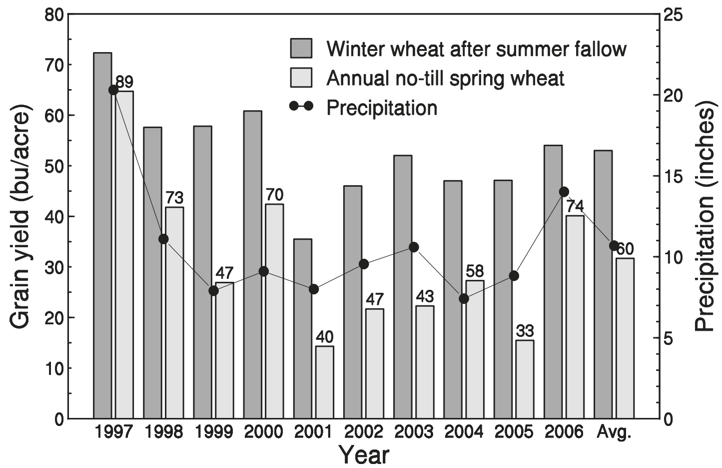


Fig. 1. Grain yield of soft white winter wheat after summer fallow (one crop every two years) vs. continuous annual no-till soft white spring wheat near Ritzville, WA from 1997 to 2006. The numbers above the bars are the percent grain yield of annual spring wheat compared to winter wheat-summer fallow for each year. Note that annual spring wheat is competitive with WW-SF in wet years but has low grain yields and lacks the stability of WW-SF during dry years.

Rodweeding Frequency and Timing Effects on Seed-Zone Water Retention in Summer Fallow

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

A 3-year field study was initiated in 2006 at the WSU Dryland Research Station at Lind to evaluate the frequency of rodweeding operations on seed-zone moisture retention and several other agronomic and environmental factors. In mid April, primary spring tillage was conducted to a depth of 5 inches. Aqua nitrogen fertilizer was injected into the soil with the undercutter sweep implement during the one-pass primary tillage. Subsequent rodweeding operations were conducted at the 4-inch depth with a Calkins center-drive rodweeder. Treatments are:

1. No rodweeding (i.e., check). Weeds are controlled with a glyphosate herbicide with a sprayer as needed to maintain weed-free plots.
2. Rodweed only when required to control weeds (this will range from 1 to 3 rodweedings, depending on the year, but only one rodweeding was required in 2006).
3. Rodweed immediately after primary spring tillage, but thereafter only as required to control weeds (as per treatment no. 2, above).
4. Rodweed immediately after primary spring tillage and then at one-month intervals until late July-early August. This was a total of five rodweedings.

Results for 2006 show that, following a wet 2005-2006 winter season, rodweeding was not required to maintain adequate seed-zone moisture for late planting. The primary tillage alone (in this case mid April with a Haybuster undercutter sweep) was the only operation required to retain seed-zone moisture. Surface residue and surface clod mass are reduced with increased rodweedings (Fig. 1). The undercutter only treatment (i.e., no rodweedings) had relatively low surface clod mass (Fig. 1) because individual clods were difficult to identify as they had “fused” together during spring rain events. The undercutter only treatment maintained a highly crusted surface that provided excellent control for wind erosion throughout the fallow cycle. There was a much higher quantity of subsurface clods in the reduced rodweeding treatments compared to the 5x treatment but, as previously documented by Schillinger and Papendick (SSSAJ 1997), subsurface clods do not appear to reduce seed-zone water content in tilled summer fallow. Excellent stands of winter wheat were achieved in all treatments in 2006.

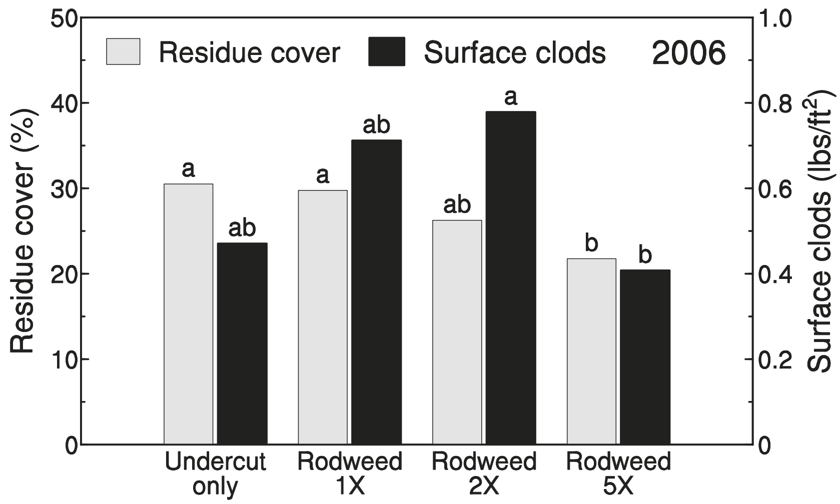


Fig. 1. Percent residue cover and surface clod mass in summer fallow just prior to planting winter wheat in late August 2006 at Lind with three rodweeding frequency and timing treatments plus the undercutter only check. Within residue cover and surface clod mass means followed by the same letter are not significantly different at $P < 0.05$.

Grain Yield and Available Moisture Relations for Winter Wheat after Fallow and Recrop Spring Wheat

W.F. SCHILLINGER, S.E. SCHOFSTOLL, J.R. ALLDREDGE, AND T.A. SMITH, DEPT. OF CROP AND SOIL SCIENCES AND DEPT. OF STATISTICS, WSU

In last year's (2006) CSS Field Day Abstracts, we reported on the similarity of wheat grain yield and available moisture relations reported by G.E. Leggett from 1953-1957 and by W.F. Schillinger et al. from 1993-2005. Those data sets combined grain yield of winter wheat after summer fallow, recrop winter wheat, and recrop spring wheat.

Today, we report available moisture and grain yield relations for winter wheat after fallow compared to recrop spring wheat from 1993-2005. For winter wheat after fallow, we partitioned available moisture into: (i) soil moisture available in fallow at time of planting in late August-early September, (ii) soil moisture stored in the soil over the winter, (iii) April rainfall, (iv) May rainfall, and (v) June rainfall. For recrop spring wheat we, of course, used only factors (ii) through (v) above in the analysis. Multiple regression statistical methods were used to calculate the relative contribution of available moisture to grain yield. All growing-season (April, May, June) rain was

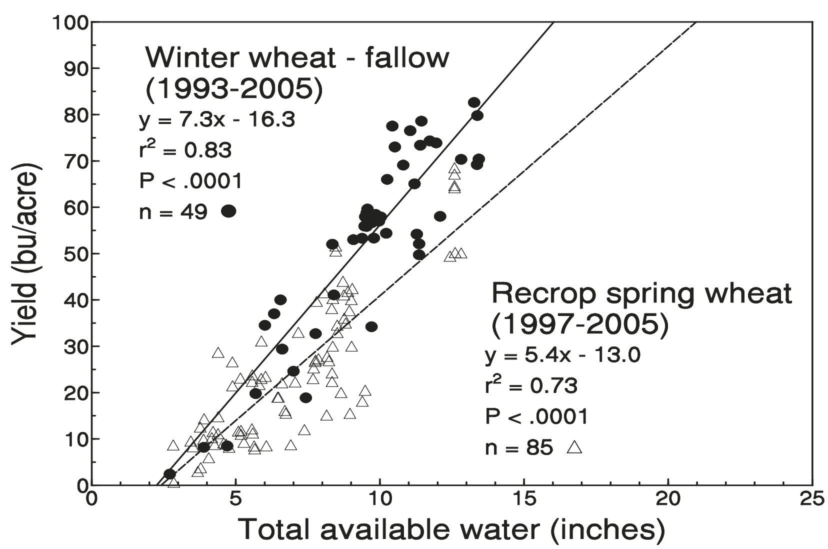


Fig. 1. The relationship between available soil moisture and grain yield for winter wheat after fallow (solid line, filled circles) and for recrop spring wheat (dotted line, open triangles) in Eastern Washington.

considered available. For both winter wheat and spring wheat, 2.5 inches of available moisture was required just for vegetative growth (Fig. 1).

For winter wheat, each inch of available soil moisture in fallow at time of planting provided 6.7 bushels of grain. For each inch of water stored in the soil during the winter (beyond what was present at time of planting), 7.9 bushels of grain was produced. Each inch of rain in April, May, and June accounted for 4.4, 7.6, and 12.2 bushels of grain, respectively (Fig. 1). Each inch of available soil moisture at the time of planting recrop spring wheat provided 5.4 bushels of grain whereas April, May, and June rainfall generated another 1.4, 6.4, and 5.7 bushels, respectively (Fig 1).

Our analysis shows that winter wheat makes much more efficient use of both stored soil moisture and growing season rainfall than does spring wheat. April rainfall is less beneficial to both winter wheat and spring wheat grain yield compared to rain in May and June. The main objective of this work is to provide farmers a decision tool, based on available soil moisture in the spring and historic growing-season rainfall, to determine when to plant spring wheat, or instead make summer fallow. This tool may also be useful for farmers who produce hard red winter wheat to help determine the quantity of nitrogen to topdress in the spring to meet grain protein requirements. A full write up of our findings will be published and available to farmers in the near future.

On-Farm Testing to Adopt No-Till Fallow Winter Wheat Production in the Dryland Cropping Region of Eastern Washington

AARON ESSER, WSU LINCOLN-ADAMS AREA EXTENSION, RICK JONES, LINCOLN COUNTY PRODUCER COOPERATOR

WSU Lincoln-Adams Extension on-farm testing helps improve farm profitability in a manner that reduces erosion and improves air quality. Winter wheat (WW) (*Triticum aestivum* L.) production on tillage based summer fallow systems has been a standard practice in the dryland cropping region (14 inches precipitation annually) of eastern Washington for generations. This has been profitable; but it comes at a cost, including soil loss through wind and water erosion. Producers have examined alternative methods including no-till systems for increasing profitability and reducing soil erosion. An on-farm test was established in 2003 examining WW established under three treatments; 'conventional' tillage fallow system, 'no-till early', or seeded at the same time as the conventional treatment, and 'no-till late', or planting was delayed one month. Conventional tillage fallow methods include a chisel sweep and cultiweeding for weed control. No-till fallow methods include chemical applications for weed control. The test is a RCBD with 5-replication. Plots are one acre in size, and seeded, maintained, and harvested by the producer. No difference in soil moisture has been detected between treatments. Grain yield differences were not detected between conventional and no-till early treatments averaging 79-bu/acre, but the no-till late treatment reduced yield 19%. Economic return above variable costs were greater with the no-till early and conventional treatments averaging $143 and $137/acre respectively, compared to only $104/acre with the no-till late treatment. Overall larger agronomic and economic differences were detected between the two no-till treatments, and little differences were detected between conventional and no-till early treatments.

Fall Fertilization for Spring Wheat Production in the Dryland Cropping Region of Washington

AARON ESSER, WSU LINCOLN-ADAMS AREA EXTENSION, CHRIS LANEY, LINCOLN COUNTY PRODUCER COOPERATOR, STEVE SWANNACK, WHITMAN COUNTY PRODUCER COOPERATOR, AND RICH KOENIG, WSU EXTENSION SOIL FERTILITY SPECIALIST

Producers throughout the dryland cropping region (8-14 inches precipitation) of Washington continue to adopt conservation tillage leading to increased spring wheat (SW) (*Triticum aestivum* L.) production. Fall applied nitrogen for SW production is of interest to manage workload, capture historically lower fertilizer prices, and improve grain protein in hard wheat. At risk is leaching nitrogen lower in the soil profile below the root zone costing producers and the environment. A series of on-farm tests were completed examining 'fall' vs. 'spring' applied nitrogen for SW production. Aqua nitrogen was applied with a low disturbance coulter applicator. Fall applied nitrogen was applied after soil temperatures fell below 50ºF to inhibit movement. Seeding was completed in one-pass with starter fertilizer being applied. The tests were carried out over three years at two sites in a RCBD with four replications. Fall applied nitrogen remained in the top foot of the soil profile at the time of seeding.

Differences in grain yield were detected between years and sites but were not detected between treatments with an average of 28.3 bu/ac. Similar results were discovered in grain protein and test weight. Economic return over nitrogen costs were greater with the fall treatment averaging $79.80/ac compared to $72.50/ac with the spring treatment due to lower fall fertilizer prices. Overall fall nitrogen applied late had no negative impact on yield and grain quality, giving producers opportunities to improve time management and capture lower fertilizer prices with limited nitrogen movement below the root zone.

Phosphorus and Seeding Rate Management to Improve Yields of Late-Planted Winter Wheat in the Low Rainfall Zone

ERIC HARWOOD, RICH KOENIG, DEPT. OF CROP AND SOIL SCIENCES, WSU; AARON ESSER, WSU EXTENSION

Dryland wheat growers in the low rainfall zone of eastern Washington commonly employ winter wheat-tillage fallow rotations. Annual cropping or chemical fallow reduces wind erosion in this susceptible area. However, late seeding is often required in these situations due to a lack of seed zone moisture at normal planting times. The objective of this study was to determine if phosphorus (P) and/or seeding rates could be altered to improve late seeded wheat yield in recrop or chemical fallow situations. Winter wheat was grown at three locations in eastern Washington in 2004-05 and two locations in 2005-06. One site was chemical fallow and the others winter wheat stubble (recrop) at the time of seeding. Seeding rates of Eltan winter wheat were 40 and 70 lb/acre. Phosphorus rates were 0, 20, 40, 60, and 80 lb P_2O_5/acre in 2004-05, and 0, 10, 20, 40, and 60 lb P_2O_5/acre in 2005-06. The chemical fallow site also had both early and late seeding dates. There was a small but uneconomical increase in grain yield with P application, and no positive effect of increasing seeding rates, at recrop sites. At the chemical fallow site there was a 9.6 bushel/acre (25%) yield response to 20 lb P_2O_5/acre in 2004-05 and a linear response (7 lb P_2O_5/bushel yield increase) to applied P at the 40 lb/ac seed rate, but no response at 70 lb seed/ac, in 2005-06. Responses to P fertilizer occurred in chemical fallow even though soil test P levels were marginal or adequate. Increasing the seed rate from 40 to 70 lb/acre increased yield by 3 bu/acre regardless of planting date at the chemical fallow site. Overall, results indicate a potential to improve wheat yields with P application and, to a lesser extent, increased seeding rates, in chemical fallow regardless of early or late seeding date. The ability to increase yields with P fertilizer or higher seeding rates in an annual cropped system are limited.

Soil Acidity and Lime Responses in Eastern Washington

PAUL CARTER, WSU EXTENSION; TABITHA BROWN, FORMERLY OF WSU NOW USDA-NRCS; LYNDON PORTER, USDA-ARS; DAVID HUGGINS, USDA-ARS; DON WYSOCKI, OREGON STATE UNIVERSITY; RICHARD KOENIG, WSU

Soil quality and conservation is improved with minimum or no-tillage farming practices. Soils of the Palouse region of Washington, Oregon, and Idaho have developed stratified layers of acidity when tillage is reduced or eliminated. Some soil pHs have become relatively acidic ($pH < 5.0$) in the surface 6 inches; however, it is not known whether this acid layer is impacting crop yields. The objective of this research was to determine the influence of lime rate on wheat, pea, and other rotational crop yields and, if necessary, to develop lime recommendations for cropping systems in the Palouse region. On-farm studies were established in fields under continuous no-till or reduced-tillage management. Treatments include a non-treated control, elemental sulfur application at 2,000 lb/acre (to accelerate acidification), and applications of pelletized lime at rates of 2,000, 4,000 and 10,000 lb/acre. Initial soil samples were collected at depths of 0 to 6 and 6 to 12 inches, and in ½-inch increment to a depth of 6 inches to characterize initial soil pH conditions. Soil pH (0 to 6-inch depth) ranged from 4.9 to 5.6. Detailed sampling indicated an acidic band at the 1 to 3-inch depth in no-till systems. Soil pH in this acidic band is as low as 3.9 at some locations. Even though soil pH is apparently below critical levels for crops grown in the Palouse area, yield responses to lime have been inconsistent. Recent evidence suggests this may be due to high organic matter levels in reduced tillage systems that reduce the incidence of aluminum toxicity associated with low soil pH. Monitoring of these long term trials is ongoing.

Phosphorus Dynamics and Wheat Response to Applied P in a Spatially Variable Environment

RICH KOENIG, DEPT. OF CROP AND SOIL SCIENCES, WSU

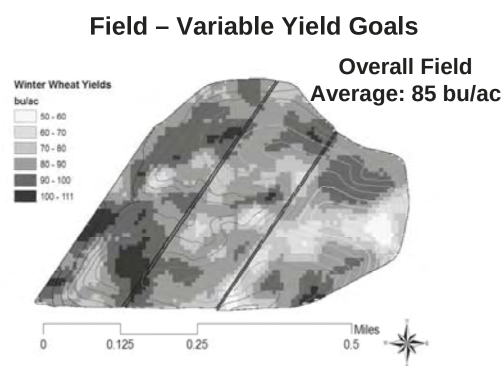
Read the full article on the web

Considerable spatial and temporal variability exists in soil chemical and physical properties across farm landscapes in eastern Washington. The purpose of this ongoing research is to investigate changes in phosphorus (P) mineralogy across Palouse landscapes and ultimately to determine the influence of mineralogy on plant-available P and fertilizer responses at different landscape positions and across the diverse dryland farming environments of eastern Washington. Soil samples were collected from locations with varying soil pH and soil test P concentrations. Mineral fractionation analysis revealed that, even though soil pH averaged 5.3 among samples, less than 2% of total soil P was associated with iron (Fe)- and aluminum (Al)-P minerals, while 65% was associated with calcium (Ca)-P minerals. A working hypothesis is that P minerals are currently in various states of transition from Ca forms, which dominated when soil pH is neutral or alkaline, to Fe/Al forms, which are predicted to dominate at lower soil pH. Sorption isotherms indicate differences in P retention among soils, with expectedly higher P retention in soils with low pH (<5.5) compared to soils with high pH (>6.5). Responses to P fertilizer (20 lb P_2O_5/acre) placed in a deep band with nitrogen beneath the seed row ranged from 5 to 10 winter wheat bushels/acre in chemical and summer fallow systems in dry areas, to 19 bu/acre in spring wheat at a ridge top landscape position. These responses were not always predicted by soil test P levels using either sodium bicarbonate or sodium acetate extracts.

Precision N Management of Wheat

DAVID HUGGINS, SOIL SCIENTIST, USDA-ARS, PULLMAN, WA

Spatial variation in yield and protein across fields is well documented for dryland wheat producing regions of the PNW. Large within-field variation in wheat performance arises from landscape and soil attributes that produce complex spatial and temporal variations in available water, organic matter and rooting depth. Current N management recommendations for dryland wheat in the Inland Pacific Northwest (PNW), however, were largely developed on a regional scale for the uniform, whole-field application of N. Tailoring N management prescriptions to site- and time-specific conditions could substantially improve N use efficiency (NUE). However, despite the availability of precision agricultural technologies there are currently no site-specific N management recommendations for the region and little grower adoption. The major barrier to adoption of precision technologies for N management has been the lack of their integration into a grower-oriented monitoring, application and evaluation system that assesses tradeoffs and optimizes the economic and environmental performance of N use. Our research objectives are to: (1) measure and predict site-specific variables required for making N management decisions on research conducted at the Washington State University (WSU) Cook Agronomy Farm; and, (2) test and evaluate site- and time-specific N management decisions as compared to uniform N management at the WSU Cook Agronomy Farm.



Preliminary evaluation of precision agricultural technologies showed that on-combine grain yield and protein monitors show promise as useful tools to characterize site-specific variations in crop performance. Variable rate applicators were shown to be proficient at achieving targeted site-specific application goals. First year comparisons of uniform versus precision N management in hard red winter wheat showed that similar yield and protein goals were met with 20% less applied N in the field-scale precision N treatment and greater N use efficiency than was achieved with uniform N management.

Urea and Ammonia Volatilization in Dryland Grass Seed Production Systems

RICHARD KOENIG, CHRISTOPHER PROCTOR, WILLIAM JOHNSTON, CHARLES GOLOB, DEPT. OF CROP AND SOIL SCIENCES, WSU; C. RICHARD SHUMWAY, SCHOOL OF ECONOMIC SCIENCES, WSU

Read the full article on the web

With the recent loss of ammonium nitrate from the marketplace, grass seed growers in dryland areas of eastern Washington and northern Idaho were forced to begin using alternative nitrogen (N) sources. The purpose of this study was to evaluate the influence of grass seed production conditions and management practices on NH_3 volatilization, Kentucky bluegrass seed yields and N recovery from urea-based N sources. This abstract reports preliminary results of an anticipated three-year study. Laboratory measurements suggest the potential for NH_3 volatilization is greater from stands in which post-harvest residue is baled and removed than from stands in which residue is burned. Both burned and unburned stands have a post-harvest surface pH above 7.9, although pH declines rapidly with time in the burned system. While the burned stand had higher surface temperatures on sunny days, burning also lowered urease enzyme activity, which should reduce the potential for NH_3 volatilization. Preliminary results from the field were similar to those in the lab, indicating higher rates of NH_3 volatilization from a bluegrass stand that was not burned. Rates of NH_3 volatilization were also higher with urea and fluid urea ammonium nitrate (UAN) applied in mid-November compared to early October, presumably due to a higher soil moisture content in November. Kentucky bluegrass seed yield and N recovery will be measured at three locations in the 2007 field season.

Canola and Other Oilseed Crops - Potential for Biodiesel

AN N. HANG AND HAROLD P. COLLINS, SEPT. OF CROP AND SOIL SCIENCES, WSU AND USDA-ARS PROSSER.

Spring canola, mustard, safflower and soybean were planted in Paterson during the last 3 years to serve as demonstration and crop rotation in potato cropping system as well as to study the feasible potential for oil seed production on irrigated sandy soil. Nine lines of spring canola were planted in 2006 for selecting adapted cultivars. Management practices for spring canola on sandy soil were somewhat different than on the loam soil or dry land cropping system. Stand establishment and weed control is very important. In sandy soil, soil temperature is somewhat higher than other soil types, this will be beneficial to early planting and stand establishment. Early planting spring canola will help plants to escape from the summer heat that is very detrimental to bloom and seed set. Yield varied from 1260 lb to 1925 lbs/a, lower than what expected due to late planting (early planting were destroyed by the storm).

Mustard was also tested in Paterson using 4 lines. Among these, Idagold performed well on sandy soil and yielded about 2360 lbs/a. *Sinapsis alba* also perform well on sandy soil with frequent irrigation. Their yield was slightly lower than Idagold.

Two SeedTec safflower lines were planted and yield ranged from 3410 to 3740 lbs/a. Weed control in safflower is the most important factor to contribute to high yield and seed quality.

Soybean of maturity group 00 and 0 can mature and harvest by direct combining in central Washington. Yield varies from year to year and from 40 to 70 bushels per acre (1 bu= 60 lbs).

Another Brassica family (old) crop can be beneficial to growers to provide healthy oil for edible market and quality meal for livestock. It is Camelina (*Camelina sativa* L.), a Brassica family with high omega-3 fatty acid, high quality meal (as soybean meal) and very short growing season (75 to 78 days after planting in central Washington). It will have potential as second crop after pea or winter wheat. This crop can tolerate odd weather conditions and possesses plant allelopathy which has ability to produce phytotoxin to compete with weed.

Canola Crop Research and Technology: Assistance to the Colville Confederated Tribes

D. ROE, USDA-NRCS

In February 2006, members of the USDA Root Disease and Biological Control Unit in Pullman, WA and a USDA NRCS conservationist in Pullman, WA responded to a request for assistance on the feasibility of growing crops to supply energy at the Colville Confederated (CC) Tribal lands at Nespelem. A small USDA team met with the CC Tribal Business Council to receive guidance and clarification on the tribal needs. An estimated 7000 gallons of diesel fuel is consumed in the 248 Tribal logging trucks used daily during most of the year. The CC Tribe would like to become fuel self-sufficient by processing crops grown and processed there.

The USDA team consulted with the USDA-NRCS persons at Nespelem to find interested cooperators to try growing canola, an oilseed crop. Local knowledge concluded it had not been grown before, at least to their knowledge.

Two Tribal members were willing to try some plots of canola in April of 2006. One plot location was in the Desautel area near Omak, and the other was near Nespelem. The USDA determined the soil, climate, and vegetation of the sites. Average precipitation is 14-16 inches.

In July and August of 2006, the Team brought a harvester to the two plot sites, and harvested the plots. The yields were higher than expected, 1100 lbs. per acre at Desautel, and 1500 lbs. per acre at Nespelem.

In October, 2006, the Team brought an oilseed crusher from the University of Idaho, and demonstrated the oilseed crushing process for a members of the Tribal Conservation District and a former member of the Tribal Business Council. The Tribal farmer at Nespelem took the oil and meal to cook with, and to feed to his livestock.

In August and September, Winter canola plots were established by the Team with 3 Tribal farmers, at Nespelem and in the Desautel area. The purpose is to see if the winter canola varieties will withstand the cold winter temperatures. Plants emerged at all three locations. The winter canola survived at all three plots, with geese damage at one location.

In January of 2007 oilseed crushing and scientific methods to create biodiesel from crushed canola oil were demonstrated by USDA and WSU Team members for the for 5^{th} through 9^{th} grade students at schools in Nespelem and near Omak. Approximately 100 students participated.

Plans are underway to assist more Tribal farmers in 2007 with plots, and with fields, of spring and winter canola. Interest is high with cautious optimism about the potential of the Colville Confederated Tribes growing fuel from the sun.

Transitioning to Certified Organic Dryland Farming in Eastern Washington: Agronomic Aspects

E. PATRICK FUERST, IAN BURKE, DENNIS PITTMANN, AMANDA SNYDER AND RICHARD KOENIG, DEPT. OF CROP AND SOIL SCIENCES, WSU; KATHLEEN PAINTER, CENTER FOR SUSTAINING AGRICULTURE AND NATURAL RESOURCES, WSU; ROBERT GALLAGHER, PENNSYLVANIA STATE UNIVERSITY

Certified organic grain production in eastern Washington presents many challenges in the areas of weed control and soil fertility. Robert Gallagher, former weed ecologist in the Department of Crop and Soil Sciences, initiated a USDA-funded Organic Transitions Study at the Boyd Farm near Pullman in spring, 2003. The purpose of this project was to evaluate the trade-offs among weed management, soil quality, and economics that occur during the three-year transition to certified organic production in eastern Washington dryland, cereal-based cropping systems. The study examined nine different crop rotations ranging from intensive grain production to intensive legumes for forage or green manure, as well as systems with alternating cereal grains and legumes. In 2006, the entire study was sown to certified organic spring wheat. Increasing the frequency and intensity of legumes managed as green manure or forage during transition resulted in higher wheat yields, better weed control, and improved soil fertility than rotations with a higher frequency of spring cereals or spring peas. Intensive grain production during the transition-phase, in which wheat, barley, and/or spring peas were harvested each year, resulted in spring wheat yields averaging 34 bushels/acre and 10% protein (HRSW) versus intensive legume systems with three years of green manure or alfalfa forage averaging 58 bushels/acre and 12% protein (HRSW). Overall, alfalfa was the most promising transition system because of highest wheat yield (61 bushels/acre), lowest weed biomass, and greatest economic potential (see abstract by Painter et al., elsewhere in these proceedings). Winter peas were very promising as green manure to build soil fertility and control weeds. This project is continuing, with all cropping systems being sown with winter wheat in fall, 2006.

Chaff and Straw Spreader Attachment for a Plot Combine

W.F. SCHILLINGER, T.A. SMITH, AND H.L. SCHAFER, DEPT. OF CROP AND SOIL SCIENCES, WSU

Commercially available plot combines are not equipped with chaff and straw spreaders. We fabricated a chaff and straw spreader for a Hege 140 plot combine for harvesting several different crops in long-term cropping systems experiments. A high-pressure radial blade blower fan was mounted behind the engine on a flat area above the sieves (Fig. 1). The fan is powered by a belt drive from an accessory pulley on the engine. A simple spring loaded idler sheave was added to the belt drive assembly to maintain belt tension and minimize vibration. With the combine engine at full throttle driving the fan pulley at 2000 revolutions per minute, the fan moves 30 cubic meters air per minute at 248 pascal. A simple dual outlet manifold was constructed from rectangular steel tubing, capped with flat plate, and ported to attach flex hose (Fig. 1) to provide air delivery along both sides of the combine to the distribution pipes.

The two PCV distribution pipes were centered across the width of the upper and lower sieves (Fig. 2). Small metal deflectors made out of scrap tin were attached with screws near the holes and bent to adjust the air velocity and direction. The distribution pipes were attached to the support structure underneath the sieves with U-clamps. The U-clamps provide a simple means of changing the angle of the air outlets relative to the residue flow from the back of the combine. Total cost and time for fabrication and installation of the chaff and straw spreader was $710 for materials and 15 hours of labor. Once air velocity, distributor angles, and air deflectors are set, operation of the chaff and straw spreader does not require active operator control.

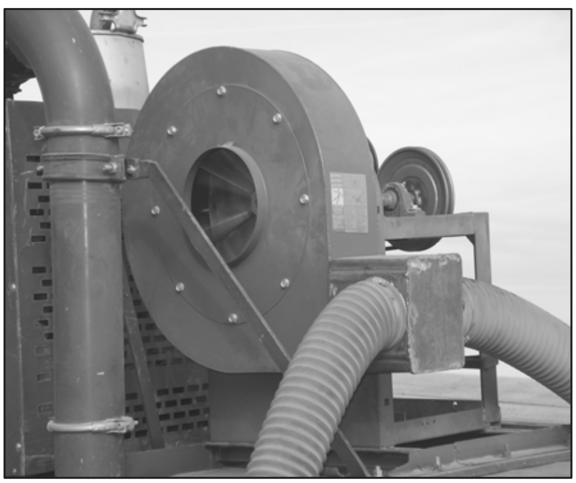


Fig. 1. Fan with attached dual outlet manifold and flexible ducting hose mounted behind the engine of a Hege 140 plot combine.

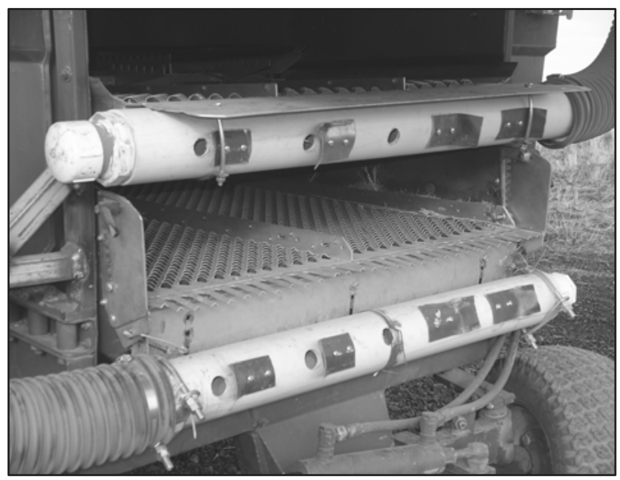


Fig. 2. Air distribution pipes with holes and deflectors mounted just below the upper and lower sieves.

Part 4. Economics and Sustainability

A Pilot Study of Yield and Protein Response to N for Dryland Spring Wheat Classes in Eastern Washington Using Variety Testing Data

DOUGLAS YOUNG[1], RICHARD KOENIG[2], JOHN BURNS[2] AND SASI PONNALURU[1]
1. SCHOOL OF ECONOMIC SCIENCES, WSU
2. DEPT. OF CROP AND SOIL SCIENCES, WSU

This was a pilot study funded by the Washington Wheat Commission to determine what useful information on spring wheat yield and protein response to N might be gleaned from data collected by Washington State University's Uniform Cereal Variety Testing Program in eastern Washington. The study revealed that the variety testing data set was insufficient by itself to design N management recommendations. Despite many statistical models tried, the goodness of fit was typically low, statistical significance was poor, and many of the estimated coefficients were inconsistent with agronomic theory.

The reason for difficulties in measuring relationships between N and yield and protein was a lack of systematic dispersion in N levels in the variety testing data. This is not surprising since the trials were designed to compare spring wheat varieties at recommended and uniform fertilization levels. Comparisons of results from the cereal testing data to those from designed N response experiments showed substantial gains from the latter. Support to continue and expand properly designed N response experiments for different wheat classes and precipitation zones should be a priority in an era of increasing fertilizer costs and volatile crop prices.

Despite the limitations of estimated N response functions, many useful general results were obtained from this pilot study. Comparisons of means of yield, protein, test weight, soil N, soil moisture and soil organic matter across precipitation regions generally confirmed expectations. These results provide a useful benchmark data base, never previously assembled, for future research and extension programs. Some useful general conclusions also emerged from the statistical N response analysis. For example, statistical results showed that including soil moisture and organic matter variables improved estimates of N response. These results further reinforce the case for more extensive soil testing to permit more precise recommendations to farmers.

Field Investigation and Computer Modeling of Water Erosion

JOAN Q. WU[1], DONALD K. MCCOOL[2], SHUHUI DUN[1], PRABHAKAR SINGH[1], R. CORY GREER[3]
[1] DEPARTMENT OF BIOLOGICAL SYSTEMS ENGINEERING, WASHINGTON STATE UNIVERSITY, PULLMAN, WA
[2] USDA-ARS-PWA, PULLMAN, WA
[3] USDA-NRCS, ONTARIO, OR

The US Pacific Northwest (PNW) is one of the regions highly prone to water erosion in the world. The unique winter rain and snow season, steep slopes, intermittent freeze and thaw of soils, and improper management practices contribute to the excessive soil loss. During thawing periods, soil strength is reduced and storm events can easily detach and transport the soil. Elevated erosion and sedimentation not only deteriorate the environment but also reduce agricultural productivity. Yet tools for quantifying water erosion under winter conditions have been lacking. Over the last decade, researchers at WSU, in collaboration with scientists at the USDA Agricultural Research Service and Forest Service and through funding support of the USDA NRI and USGS, have devoted tremendous efforts to field investigation of water erosion processes as well as continued modification, development and application of the USDA's WEPP (Water Erosion Prediction Project) model.

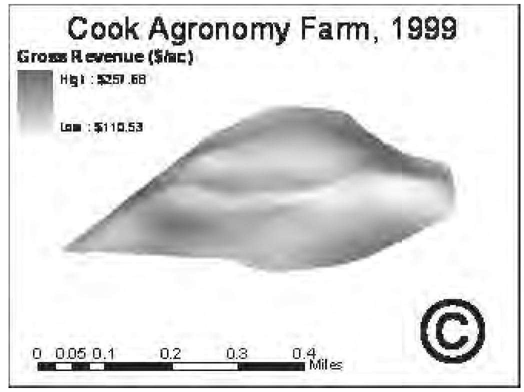
Long-term erosion research plots were instrumented and monitored for the winter seasons of 2003–2007 at the Palouse Conservation Field Station (PCFS) near Pullman, WA. Hydrologic and erosion impacts of two representative tillage treatments: conventionally tilled “black fallow” and no-till with direct-seeded annual winter wheat (*Triticum aestivum L. cv. Madsen*), have been evaluated. In addition to an automatic weather station, instruments were installed to measure winter runoff and erosion, soil water and temperature, frost and thaw depths. The comprehensive data allow for a better understanding of the water movement and heat transfer in soil profile, which affects surface runoff and water erosion.

Efforts on field testing and computer modeling of water erosion have led to promising outcome, including a number of refereed research articles in premium hydrology journals and several updates of the WEPP model. A new release based on recent modifications to WEPP winter hydrology routines will soon be published on the website of the USDA National Soil Erosion Research Laboratory (http://topsoil.nserl.purdue.edu/nserlweb/index.html).

Economics of No-till Cropping Systems Across the Landscape

KATE PAINTER, SCHOOL OF ECONOMIC SCIENCES, WSU; , DAVE HUGGINS, USDA-ARS; MIKE ENSLEY, GROWER

The performance of various crops and rotations vary considerably across different locations of a typical Palouse field. In 2001, six different crop rotation strategies under continuous no-till were established at the WSU Cook Agronomy Farm. By harvest in 2006, each rotation had completed two cycles and we present an evaluation of crop performance (yield, protein, economic return) across the 92 acre research farm. Preliminary data show field locations with widely divergent economic returns that may prove useful for improving decisions on land management.



Gross returns of hard red spring wheat in 1999.

Crop Residue Use: Evaluating Trade-offs

DAVID HUGGINS, USDA-ARS; CHAD KRUGER, CENTER FOR SUSTAINING AGRICULTURE AND NATURAL RESOURCES, WSU; AND HANS KOK, WSU/UI EXTENSION

Conversion of crop residue biomass to bio-energy has captured the interest of farmers, governmental representatives and the public. In part, this has occurred as reported on-farm inventories of biomass indicate a large quantity of available feed-stocks (crop residues) that could be used to produce bio-energy through, for example, cellulosic fermentation or pyrolysis. What are the trade-offs? Will removal of crop residues further decrease soil organic matter and degrade the soil resource base? What are potential impacts on crop rotation, fertilizer and pesticide use and other farming practices? Will farmers be trading long-term sustainability for short-term gain? In order to answer these questions we assessed trade-offs associated with different crop residue management options, particularly impacts on soil carbon sequestration, crop nutrient removal, soil erosion and energy production. This assessment is derived from field-scale research conducted at the Washington State University Cook Agronomy Farm near Pullman, WA. Preliminary analyses indicate: (1) energy production from baled straw averaged 2000 kW hours per acre; (2) residue removal during cereal portions of rotation would likely decrease soil organic matter across the whole field; (3) The Soil Condition Index remained positive when residue was baled and removed under continuous no-tillage; (4) nutrients removed per acre ranged from 9 to 34 lbs N, 3 to 13 lbs P_2O_5, 2 to 8 lbs of S and 20 to 77 lbs of K.

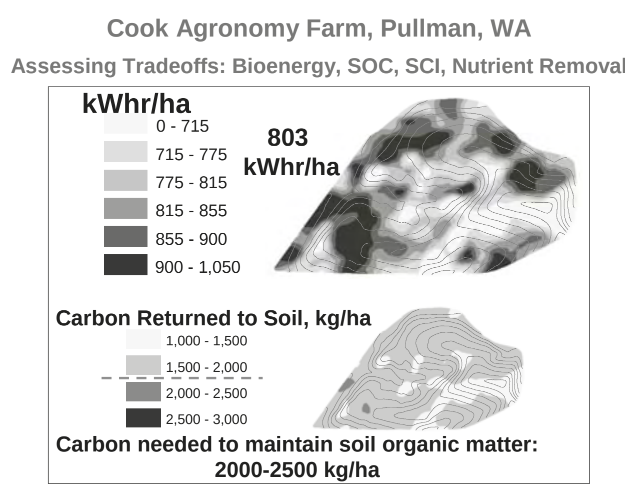
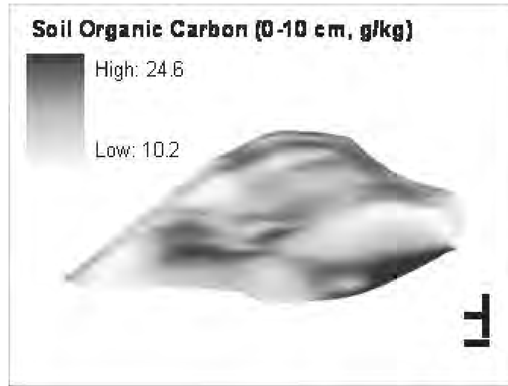


Figure 1. Baled residue produced on average 803 kWhr/ha of energy (about 2000 kW hours/ac) but reduced the return of C in remaining residue to amounts below critical levels needed to maintain soil organic matter.

Soil Carbon Sequestration and Trading

DAVE HUGGINS, USDA-ARS; CLAUDIO STOCKLE, BIOLOGICAL SYSTEMS ENGINEERING, WSU; DAVID BROWN, DEPT. OF CROP AND SOIL SCIENCES, WSU; AND RUSS EVANS, PACIFIC NORTHWEST DIRECT SEED ASSOCIATION

Greater storage of soil carbon (C) often occurs when agricultural fields are converted from intensive tillage to no-tillage. Atmospheric carbon dioxide, a greenhouse gas, provides the source of C for increases in soil organic matter storage (soil organic matter is about 58% C). Consequently, capturing carbon dioxide from the atmosphere and transforming it into soil organic matter through the use of no-till farming has been proposed as a strategy for reducing atmospheric carbon dioxide. Currently, markets are developing for C trading in the U.S. and increases in soil C storage may return economic value to farmers. The ability to market soil C storage will likely depend on several factors including: (1) measurement technologies to assess levels of soil carbon in the field; and (2) methods to evaluate and predict farming practice effects on changes in soil C storage over time. Current research at WSU and USDA-ARS addresses these factors and we present information on the latest developments.



Soil Carbon storage in the top 4 inches (10 cm) of soil at the WSU Cook Agronomy Farm.

Economics of Transitioning to Organic Grain Production: Boyd Farm Trials, Pullman, WA, 2003-2006

KATHLEEN PAINTER AND HERB HINMAN, SCHOOL OF ECONOMIC SCIENCES, WSU; E. PATRICK FUERST, IAN BURKE, RICHARD KOENIG, DENNIS PITTMANN, AMANDA SNYDER, AND BYUNG-KEE BAIK, DEPT. OF CROP AND SOIL SCIENCES, WSU; ROBERT GALLAGHER, PENNSYLVANIA STATE UNIVERSITY

Few organic dryland grain growers can be found in the highly productive grain-growing region of eastern Washington. Farmers interested in growing organic grains must first obtain organic certification for their land, which requires a three-year transition period using organic production practices. Since farmers do not receive organic premiums during this period, the transition stage can be costly.

In the Boyd Farm organic trials near Pullman, WA, nine different cropping systems were analyzed for agronomic and economic viability during the three-year transition stage. Cropping choices on 45 plots (5 replications of 9 systems) ranged from an all-grain system to an all-legume system. In the fourth year, spring wheat was planted across all treatments.

During the transition phase, all cropping systems lost money, but a forage system was the least costly, with a net cost averaging $35 per acre year over the three-year period, including interest calculated at 9% per year. Costs for the other systems ranged from an average of $117 to $174 per acre per year, including interest. Low yields and high input costs contributed to this lack of profitability. During the first year of crop production, spring wheat yields varied from 26 to 61 bu per acre across the nine treatments. Four of the nine systems either broke even or were profitable. However, if interest is calculated on expenses during the transition period and payments are amortized over the first three years of organic production, only two systems could cover their payments from crop income in the first year of organic production. The forage system had net returns to risk and management of $97 per acre and a $14 per acre amortized payment for the transition period while the green manure system had net returns of $67 per acre and a $64 per acre amortized transition payment.

Soil Conserving Undercutter System Improves Profitability for Winter Wheat-Summer Fallow in Eastern Washington

ANDREY ZAIKIN, DOUGLAS YOUNG, SCHOOL OF ECONOMIC SCIENCES, WSU; AND WILLIAM SCHILLINGER, DEPT. OF CROP AND SOIL SCIENCES, WSU

Read the full article on the web

Conservation tillage winter wheat-summer fallow (WW-SF) systems are clearly an environmental success. Engineers' have predicted that these systems reduce dust emissions by 50% during severe wind events compared to traditionally-tilled WW-SF. However, relatively few farmers in the low-precipitation region of the inland Pacific Northwest use these systems because of reluctance to change "tried and proven" traditional tillage fallow. We compared economic results from conservation V-sweep undercutter and traditional fallow tillage systems on a large case-study farm near Ritzville, Washington.

Before conservation payments, results showed the undercutter tillage method had a net return over total costs advantage of $10.92/2 acre versus $7.61 for traditional tillage. The 2 acre unit includes both the fallow and the winter wheat year. The undercutter system's net returns over total costs was markedly strengthened by conservation payments that raised the profitability comparison for undercutter versus traditional fallow to $31.32 versus $7.61/2 ac. These case-study results with and without conservation payments show that the undercutter tillage system can be economically competitive relative to traditional fallow tillage. The results showed that the case-study farm produced soft white wheat at the very competitive cost of only $3.08/bu using the undercutter method. Other farms may experience different production costs.

The annual conservation payment in this study was $20.40/2 acre. Current USDA funding is insufficient for conservation payments of this magnitude for all farmers. Nonetheless, this payment is less then one-fourth the typical annual Conservation Reserve Program (CRP) rent of $40–$50/acre in Adams County. As a promising development, in 2006 the Washington Association of Wheat Growers secured a $905,000 federal grant to provide a 50% cost-share to purchase V-sweep undercutters for 50 wheat growers in 14 counties in Washington and Oregon. The results of our study indicate that the undercutter cost-sharing program has a reasonable chance of economic success.

Adjusting Yields in Reduced Size Crop Rotation Experiments for Possible Confounding by Weather

DOUGLAS YOUNG, SCHOOL OF ECONOMIC SCIENCES, WSU; AND FRANK YOUNG, USDA-ARS

To accurately portray annual income and income rotation variability from n-crop rotations in field experiments, it is necessary to grow all crops in the rotation every year. This captures the potentially different responses of different crops to annual weather and pest variations. The appropriate economic measure is income per rotational acre whereby annual income from each crop is weighted by (1/n) and summed. Unfortunately, resource constraints may prevent growing each crop every year in some (reduced size) experiments. However, in situations where every crop is grown annually at a nearby similar site, it is possible to better approximate annual rotational returns. We did this in a recently published reduced size six-year spring wheat-winter wheat-winter wheat (SW-WW-WW) experiment by using data from a larger experiment in the same field which grew every rotational position of SW-WW-WW every year. In the reduced size experiment, only one crop was planted each year. To illustrate the adjustment procedure, consider SW. SW yields in the larger experiment were tabulated for the two years in which SW was grown in the reduced experiment. If SW yields in the larger experiment in these two years were 90% of 6-yr average SW yields on the larger experiment, then SW yields in the reduced experiment were normalized by multiplying them by (1/0.90). Similar adjustments were made for first and second year WW. This approach may help address part of the confounding from weather when each rotational crop is grown only once over a 3-yr rotation. For example, if SW, first year WW, and second year WW all happen to be grown in years that weather adversely affected these particular crops, a downwardly biased estimate of the long run average annual economic return from the rotation would be provided if no adjustment were made.

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 State University for over 50 years.

"The importance of Spillman Farm will not diminish as time passes. Multimillion dollar structures on campus will not replace its (Spillman Agronomy Farm) vital role in crop improvement. I spoke at the Spillman Farm Field Day in July of 1996, the year I retired. I said then the farm was operating on a shoestring. Well, it is still being held together by the same shoestring. It is urgent, after 50 years, this facility receive the support it deserves."
—***Bob Allan,*** retired USDA-ARS wheat geneticist

Cook Agronomy Farm Endowment Fund

Located in Whitman County, five miles northeast of Pullman, WA, the 140-acre Cook Agronomy Farm (formerly referred to as 'Cunningham Farm') includes soils and topography representative of the Annual Cropping Regions of Washington State. WSU and USDA-ARS research scientists are conducting collaborative programs to develop and implement a coordinated research program designed to meet the needs of direct-seed cropping systems in this higher precipitation region of the Inland Northwest.

Lind Dryland Research Station Endowment Fund

The WSU Dryland Research Station comprises 320 acres that was deeded to WSU 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. For 92 years, researchers at the Lind Station have released several wheat varieties and published numerous scientific articles related to agronomy, diseases, weed ecology, conservation tillage, farm economics, and drought stress physiology.

Wilke Research & Extension Farm Endowment Fund

The Wilke Research and Extension Farm is located on the east edge of Davenport, WA in the intermediate rainfall zone (12-17 inches of annual precipitation) of eastern Washington in what has historically been a conventional tillage, 3-year rotation of winter wheat, spring cereal, followed by summer fallow. The 320 acre farm was bequeathed to WSU in 1982 by Beulah W. Wilke for agricultural research and extension. WSU partnered with farmers and the agricultural industry to create a demonstration farm devoted to developing new farming systems based on annual cropping and 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.**

Representative wheat plants dug from plots in April, 1971, the second year of a 3-year winter wheat monoculture experiment at Puyallup, WA. The plants on the right (light roots) show no apparent take-all root disease and were from plots where soil taken from a 12-year wheat monoculture field near Quincy, WA had been mixed six inches deep at a rate of only 0.5% by weight before planting the first wheat crop in the fall of year one (1969), i.e. 18 months and two wheat crops earlier.

Plants with severe take-all (dark roots) were from plots amended with the same amount of soil from a non-cropped, sagebrush-vegetation site adjacent to the wheat monoculture field (center) or no soil (check; left). Take-all was uniformly severe in the first wheat crop (1969-70) and take-all decline occurred uniformly through the experimental site in the third wheat crop (1971-72), regardless of the one-time soil amendment at the start of the experiment.

This was the first experimental evidence that the spontaneous decline of the take-all root disease with continuous wheat monoculture is a real phenomenon subject to scientific understanding and effective management with cereal-intensive cropping systems.

Photo and caption by R. James Cook.