

2008 Dryland Field Day Abstracts: Highlights of Research Progress

FEATURING BIOENERGY CROPPING SYSTEMS RESEARCH

Department of Crop and Soil Sciences
Technical Report 08-1

Dedicated to Mr. R. Dennis Roe

WSU Dryland Research Station Field Day
Lind June 19, 2008

WSU Wilke Farm Farm Field Day
Davenport June 25, 2008

WSU/USDA-ARS Palouse Conservation Station Field Day
Pullman June 26, 2008



Welcome to our 2008 Field Days!

As Chair of the Department of Crop and Soil Sciences, I am proud to introduce the 2008 Dryland Field Day Abstracts: Highlights of Research Progress. This publication has a simple purpose: to introduce you to numerous research projects conducted in 2008 by WSU faculty and USDA-ARS research scientists working as part of, or in cooperation with, the Department of Crop and Soil Sciences.

Our theme this year is “Bioenergy Cropping Systems Research.” Global increases in energy demand over supply, combined with environmental concerns, have turned the spotlight on bioenergy produced from crops. In response to public appeal for home-grown bioenergy, the Washington State legislature and state agencies have turned to WSU research and Extension programs and USDA-ARS collaborators to help make that happen. We embark on this mission with cautious optimism, and with full knowledge that any real progress will require a sustained global commitment to the vision.

We are also mindful of the Department of Crop and Soil Sciences vision which states 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; provide experiential learning opportunities for students to work with world-class faculty; promote diversity of ideas, people, cultures; disseminate accumulated knowledge through resident instruction, continuing education, extension, publications, and professional contacts.”

As you will note while reading the enclosed abstracts, we are engaged in many research activities of regional and national prominence. Our 2008 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
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*2008 Dryland Field Day Abstracts: Highlights of Research Progress
Technical Report 08-1
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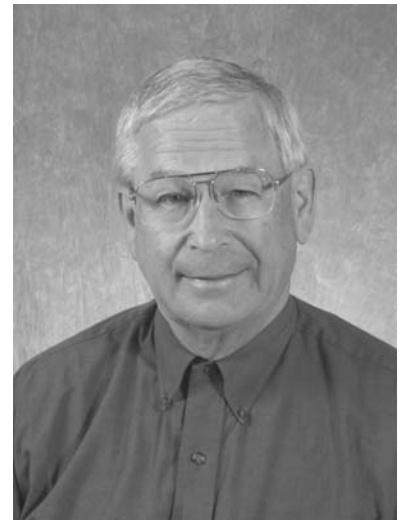
*Cover photo: Canola on the Palouse, photo by Dennis Roe
Photo this page: Mustard field, photo courtesy of Natural Resource
Conservation Service*

Dedicated to Mr. R. Dennis Roe

Reflecting on his 41 years of service to the USDA Natural Resources Conservation Service and 11 years to Washington State University, Dennis Roe credited his wife with having the biggest influence on his career as a conservation agronomist. "When in the midst of so much, she was always there to encourage me," said Roe. "We both grew up on farms and share an interest in preventing erosion."

From a boy who knew the many different sizes of wrenches before learning the alphabet, to a young man largely responsible for a 6,000-acre fourth-generation dryland farm near Goldendale, Roe set the foundation for his vocation by raising grain, hay, and livestock.

Roe received a Bachelor of Science in Agriculture from WSU in 1966. It was in his junior year during a farm management class guest lecture when the tenuous economics of farming sank in. Until then his intentions had been to take his education back to the family farm. "It's life's little moments that set your direction at the Y in the road," said Roe. He decided to leave farming, and with his parent's approaching retirement, his family sold the farm.



Hired by the NRCS in 1966, Roe served the growers of Whitman County and the Inland Northwest for his entire NRCS career, including a two-year stint in Washington, DC as part of a USDA Farm Bill team from 1995-1996. He also held an adjunct faculty appointment in the WSU Department of Crop and Soil Sciences from 1996-2007.

Elaborating on the history of NRCS, Roe described its organizational structure as based on a military framework dating back to the Civilian Conservation Corp. Traditionally, staff were expected to move every two years. A realization of changing times occurred in 1970 from a chance visit with the NRCS national personnel director, who encouraged Roe to make the best choice for himself. "For me, in terms of a promotion, my greatest opportunity was staying put," said Roe. "There have been several opportunities for advancement, from Puerto Rico to DC, but my passion was to work directly with the farmers."

At the NRCS Roe availed himself to growers trying to manage crop residue for erosion control. Over the years he helped develop 4,200 conservation plans in Whitman County, the basis for a farmer's eligibility for federal financial incentive programs. He also served on a tri-state team coordinating work among NRCS offices in north Idaho, southeast Washington, and northeast Oregon.

From 1972 to 1980 Roe evaluated field surface conditions and erosion with Verle Kaiser, former USDA-SCS conservation agronomist, then continued this work with USDA-ARS soil scientist Don McCool until 1988. McCool, then a national team member for the Soil Loss Equation model, used this data to adapt the model to the western region. This software is now used routinely by NRCS to develop conservation plans.

From 1998 to 2005, SARE research with former WSU/UI conservation tillage Extension specialist Roger Veseth provided Roe funding to complete research on seven direct-seeded farms and publish direct-seed case studies on 16 farms.

In 2002 Roe's interest in oilseed and oilseed technology moved him to collaborate with UI scientists Jack Brown, Charles Peterson, Joe Thompson, and Jon Van Gerpen. They were experimenting with oilseeds as a possible broadleaf crop in a wheat rotation, and also studying oilseed technology (i.e., biodiesel). Since then Roe has given numerous presentations and oilseed crushing demonstrations.

Roe's fondest memories over the years are many, but a common theme is seeing changes in the ways families farm from generation to generation, adopting new ideas and technology. "I can also associate the families of many of these young people today by recalling their grandfathers' faces," said Roe.

Despite retiring on June 20, 2007, Roe continues his conservation tillage research activities with Hans Kok, WSU/UI conservation tillage Extension specialist, albeit on a part-time basis. He and his wife Eileen also enjoy spending time with their four children and 12 grandchildren, all residing in the Pacific Northwest. Incidentally, Roe did manage to hang on to one acre of the family farm for sentimental reasons—"or a condo development," he joked.

(Continued on page 2)

Discovering Better Ways to Farm from a Half Century of Cropping Systems Research: 1958–2008

Invited commentary by Mr. R. Dennis Roe

Working with crops and soils goes back to my childhood, as it did in previous generations of my family. My mother's parents homesteaded at Eskridge, Kansas, and later at Goldendale, Washington, where they met my father's farming grandparents, who came from Nebraska and Vermont.

For my family, and everyone else involved in agriculture, discovery is a central theme. "Searching for better days through better ways", a phrase from the Future Farmers of America Creed, is one many of us memorized to become a Chapter member. Farmers and people supporting the work of the farmer have always looked for "better ways". My most exciting and rewarding days have been those when better ways were found.

AGRICULTURAL MILESTONES

Some new ways are earth-shaking, while others are incremental, as in a series of events toward adopting a new farming system. The one my father often spoke of was in 1930 when his father traded 32 head of draft horses and \$1,000 for a used RD-4 Caterpillar tractor. It was a very economical and time-saving move that provided land and space on the farm for a cattle enterprise on a pasture formerly used for horses.

Changing from horses to tractors was one of agriculture's milestones when I was growing up. In today's world, the discovery of foliar and soil-borne diseases is considered another milestone. We don't hear of explosions in common smut anymore, and farmers rarely experience the excruciating disappointment of seeing only a few spindly kernels in their bulk tanks as we did in 1962 when stripe rust took our wheat crop at Goldendale.

Soil erosion on the Palouse was at its worst in 1962. In February of that year, more than 17 million tons of soil was measured flowing past the Palouse River Bridge at Hooper in western Whitman County, according to the U.S. Geological Survey. In one 24-hour period, enough soil flowed past Hooper to cover 1,100 acres one foot deep.

Part of readying for the 1962 wheat harvest was using bulldozers to create crossings over the deepest gullies in order to get combines and trucks into the fields. In those days, shovels were commonly carried on wheat trucks for that purpose, and for many, erosion was only thought of to the extent that it impacted getting equipment in or out of the field.

The need to discover better ways was paramount. Fortunately, scientists at the USDA-ARS and WSU were able to show that even a dime-thick loss of soil from a field, determined to be 5 tons per acre, was too much to sustain future production. Henry W. Smith and Harley Jacquot from WSU and Verle Kaiser from the USDA-SCS began collecting this supporting data on soils, erosion, and crops in the 1930s. The newly established Palouse Conservation Field Station in Pullman, one of 10 soil erosion experiment stations nationwide at that time, provided them research assistance.

WIDE-RANGING IMPACTS

Why were our farms losing thousands of tons of soil? Erosion was soon recognized as not just a farm problem, but a community problem. The dust storms in central Washington blocked out the sun. My wife spent her first 10 years on a farm in western Walla Walla County notable for dust storms that rendered outdoor activities impossible. Her mother scurried to stuff torn rags in the window cracks of their home using a table knife in an attempt to prevent the dust from entering, but even these measures did little to alleviate the problem. Similarly, rural communities along the rivers spent hours cleaning up mud from overflowing riverbanks during the highest soil runoffs.

In 1979, USDA scientists reported that the loss of half the Palouse's topsoil had reduced wheat yields by 9 bushels per acre. Based on today's wheat price of \$9.22 per bushel, that amounts to \$36,000 on a 3,000-acre farm with 1,200 acres in wheat, enough to support another partner on a family farm.

Another early discovery was that residue from the previous crop left in place over winter reduced the soil loss from rain falling and flowing on frozen Palouse slopes. However, because of confounding issues with that finding, a lot more research had to follow before this practice was widely adopted.

First, equipment was needed to handle five-foot-tall wheat varieties from the 1930s prior to Dr. Orville Vogel's development of semi-dwarf wheat varieties in the 1950s and 1960s. In the 1940s, wheat stubble on 80% of the land on some farms was burned because it would not flow through the tillage equipment of that era. Then there was the discovery of diseases associated with wheat residue; Dr. Jim Cook's "green bridge" research led to no-till and direct seeding, a novel method for seeding crops into wheat residue.

Crop rotation was an important discovery for successful production of wheat on the Palouse because it tends to break the disease cycles in wheat. Peas and lentils were introduced for both production and green manure. In the 1960s, other crops such as canola were introduced on land set aside in the eastern Palouse. More recently, oilseed crops are of interest for their biofuel and livestock feed meal potential.

IMPLEMENTING THE DISCOVERIES

Probably the most complex discovery lay on the farmers themselves: how to make the new technology work on their own farms. The McGregor Land and Livestock Company took a bold leap in establishing an on-farm research center at Hooper, Washington, in 1946. They hired Jacquot to help them learn how to adapt cropping systems research to their large wheat farm. Part of that work was nitrate and soil moisture testing to improve the production of crop residue on slopes that suffered from years of rain on frozen soil. Most other farmers learned of ways to use new technology from WSU Extension agents, USDA Soil Conservation Service staff, local conservation districts, neighbors, and their own experiments.

These discoveries continue. Farmers find ways to fertilize wheat and control weeds and pests. They find ways to acquire land and capital for newer, larger, and more sophisticated machinery. They find ways for their children to attend Washington State University, yet have something left to live on.

It has been a pleasure to work for the past 41 years with the NRCS, ARS, WSU, and Northwest farmers to find "better days through better ways." Because of this collaboration—which required the dedication of farmers and ranchers using persistence and patience—our air, water, and soil quality are indeed better.

—Dennis Roe



THE FFA CREED

I believe in the future of agriculture, with a faith born not of words but of deeds - achievements won by the present and past generations of agriculturists; in the promise of **better days through better ways**, even as the better things we now enjoy have come to us from the struggles of former years.

I believe that to live and work on a good farm, or to be engaged in other agricultural pursuits, is pleasant as well as challenging; for I know the joys and discomforts of agricultural life and hold an inborn fondness for those associations which, even in hours of discouragement, I cannot deny.

I believe in leadership from ourselves and respect from others. I believe in my own ability to work efficiently and think clearly, with such knowledge and skill as I can secure, and in the ability of progressive agriculturists to serve our own and the public interest in producing and marketing the product of our toil.

I believe in less dependence on begging and more power in bargaining; in the life abundant and enough honest wealth to help make it so—for others as well as myself; in less need for charity and more of it when needed; in being happy myself and playing square with those whose happiness depends upon me.

I believe that American agriculture can and will hold true to the best traditions of our national life and that I can exert an influence in my home and community which will stand solid for my part in that inspiring task.

THE CREED WAS WRITTEN BY E. M. TIFFANY, AND ADOPTED AT THE 3RD NATIONAL CONVENTION OF THE FFA. IT WAS REVISED AT THE 38TH CONVENTION AND THE 63RD CONVENTION.

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 Richter, Mark—Endicott
 Roseberry, Dave—Prosser
 St. Hilaire, Bob & Phil—Wapato
 Sauer, Bruce—Lind
 Sawyer, John—Palouse
 Schafer, Derek—Ritzville
 Schibel, Jeff—Odessa
 Schmitt, Mike/Dan—Horse Heaven Hills
 Schmitz, Joe—Rosalia
 Schoesler, Mark—Ritzville
 Schultheis, Art—Colton
 Sheffels, Mark—Wilbur
 Smith, Steve—Horse Heaven Hills
 Snyder, Jerry—Ralston
 Spangler, Dennis—Connell
 Steinbock, John—WSU-Othello
 Stubbs, Jerry/Mike—Dusty
 Suess, Randy—Colfax
 Swannack, Steve—Lamont
 Takemura, Jay—Dayton
 Tanneberg, Jason—Mansfield
 Tanneberg, Larry—Coulee City
 Thorn, Eric—Dayton
 Tiegs, Brian—Fairfield
 Townsend, Ed—Omak
 Treat, Dennis—Warden
 Walters, Craig—Palouse

Wesselman, Roger—Mansfield
 White, Gil—Lamont
 Zenner, Russ—Genesee

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 Arizona Plant Breeders
 BASF
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 BNP Lentil
 Busch-Ag Resources
 BNP Lentil
 Busch-Ag Resources
 CalWest Seed
 Cedbeco Zaden BV
 Central Washington Grain Growers
 CLD Pacific Grain
 Co-Ag, Inc.
 Columbia Co. Grain Growers
 Columbia Grain Int'l.
 Connell Grain Growers
 Crites
 DOW Agrosience
 DuPont
 Empire, Inc.
 Evans Enterprises
 Fluid Fertilizer Foundation
 FMC Corp.
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 Great Plains Mfg.
 Great Western Malting
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 Harvest States
 Horsch Maschinen GmbH
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 Johnson Union Warehouse
 Land Institute
 Laughlin Trading Co.
 Lincoln/Adams Crop Improvement Assn.
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 McGregor Co.
 McKay Seeds
 Merrill Lewis
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 Micosoft Corp.
 Monsanto Co.
 Moore, Jim & Ann
 North Pine Ag Supply
 Northwest Grain Growers
 Nu Chem
 Odessa Union Warehouse Co-op
 Pioneer Seeds
 Pomeroy Farm & Home Supply
 Primeland

ProGene
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 Reardan Seed Co.
 Resource Seeds
 Ritzville Grain Growers
 Seedex
 SeedTec
 Simplot
 Small Planet Foods
 Spectrum Crop Development
 Spokane Co. Assn. Wheat Growers
 Spokane Co. Crop Improvement Assn.
 Spokane Seed
 St. John Grain Growers
 Syngenta
 Tomco Seed
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 USDPLC
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 Walter Implement Co.
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 Washington Wheat Commission
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 Western Ag Innovations
 Western Farm Service
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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 9 years have been used to obtain site-specific data and develop physical maps of the 140-acre farm, with the greatest detail developed for a 92-acre watershed using 369 GPS-referenced sites on a nonaligned grid. Maps are available or being developed from various sampling efforts that characterize crop yield and economic returns, soil types, weed seed banks, populations of soilborne pathogens, soil pH, carbon sequestration, soil water and nitrogen supplies, nitrogen use efficiency and precision N applications. This has been achieved while producing a crop of hard red spring wheat in 1999, spring barley in 2000, and initiating six direct-seed cropping system rotations starting in the fall of 2001 that have continued through today. This past year, an adjacent 160 ac were added to the overall Cook Agronomy Farm bringing the total land area to 300 ac. This new acreage will provide much needed land for small plot research that can complement larger scale cropping system efforts.

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

Dryland Research Station

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



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

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

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

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

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

Palouse Conservation Field Station

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



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

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

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

Spillman Agronomy Farm

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

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



William J. Spillman, breeding plots at Pullman, 1900

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

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

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

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

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

Wilke Research and Extension Farm

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

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

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

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

Variety History at WSU

Wheat Varieties

COMPILED BY STEVE LYON

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

SPILLMAN

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

GAINES

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

VOGEL

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

NELSON

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

ALLAN

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

BRUEHL

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

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

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

KONZAK

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

DONALDSON

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

KIDWELL

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

JONES

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

CAMPBELL

Finch 2002SWW WA bird
 Chukar..... 2002SWW Club WA bird and names clubs beginning with a 'C'
 Cara 2007SWW 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
Cougar.....	1985	spring, 6-row, feed	Ullrich	selection from Beacon // 7136-62 / 6773-71
Hundred.....	1989	winter, 6-row, feed	Ullrich	selection from WA2196-68 / WA2509-65
Crest	1992	spring, 2-row, malting	Ullrich	selection from Klages /2* WA8537-68
Bear.....	1997	spring, 2-row, hulless.....	Ullrich	selection from Scout / WA8893-78
Washford.....	1997	spring, 6-row, hay	Ullrich	selection from Columbia / Belford
Farmington	2001	spring, 2-row, feed	Ullrich	WA10698-76 // Piroline SD Mutant / Valticky SD Mutant /3/ Maresi
Bob	2002	spring, 2-row, feed	Ullrich	selection from A308 (Lewis somaclonal line) / Baronesse
Radiant	2003	spring, 2-row, feed	Wettstein	selection from Baronesse / Harrington proant mutant 29-667

Dry Pea, Lentil and Chickpea Varieties

COMPILED BY FRED MUEHLBAUER AND KEVIN MCPHEE

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

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

DRY PEASSpring Green Peas

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

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

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

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

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

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

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

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

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

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

Spring Yellow Peas

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

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

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

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

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

Winter Peas

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

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

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

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

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

LENTILSBrewer Types

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

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

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

Laird Types

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

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

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

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

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

Small-seeded Types

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

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

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

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

Turkish Red Types

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

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

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

CHICKPEAS

Kabuli Type

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Desi Type

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

Part 1. Bioenergy Cropping Systems Research

An Overview of International Crop Sources of Biofuels

DOUG YOUNG, SCHOOL OF ECONOMIC SCIENCES, WSU

Most large agricultural countries are initiating biofuel production programs. However, the most recent United Nations data show that production of most crop feedstocks is concentrated in a few countries (Table 1).

Table 1. Leading National Sources by Crop Feedstock for Biofuels, 2006

Crop	Country	Met. Ton (Mill.)	Crop	Country	Met. Ton (Mill.)
	----- Ethanol -----			----- Biodiesel -----	
Corn	USA	268	Soybeans	USA	88
	China	146		Brazil	52
	Brazil	43		Argentina	40
	Argentina	22		China	16
Sugar Cane	Brazil	455	Palm Oil	Indonesia	16
	India	281		Malaysia	16
	China	101		Nigeria	1
	Mexico	51		Columbia	1
Sugar Beets	Russia	31	Canola/Rapeseed	China	13
	France	30		Canada	9
	USA	29		India	8
	Ukraine	22		Germany	5

Source: UN-FAO, 2006

Not surprisingly, the U.S. and Brazil are the largest producers of ethanol given the U.S.' and Brazil's long-standing leadership in corn and sugar cane production. Other large producers of corn, including China, and of sugar cane, including India, have large domestic food or feed demands on these crops leaving less available for ethanol. Sugar beets are important potential ethanol feedstocks in America and in some European countries. Worldwide, potential ethanol crop feedstocks exceed biodiesel crop feedstocks by a considerable margin. The U.S., Brazil, and Argentina lead in soybean production, but use of soy for biofuel is limited by strong food demands for soy, by the fact that soy has only half the oil content compared to oilseeds like canola, and by oscillating soy acreage in the U.S. and elsewhere as corn and soybean prices fluctuate. Indonesia and Malaysia dominate in palm oil production, but environmental issues like deforestation in these countries and palm oil biodiesel quality limitations are disadvantages. Canola/rapeseed is a significant potential biodiesel feedstock from China, Canada, India, and Germany. Most analysts forecast continuing high prices for crop feedstocks as food, feed, and fuel compete for limited international supplies. This will likely direct more research in the long run toward non-food cellulosic sources like switchgrass, crop residues, forest products, and municipal waste.

An Overview of U.S. Pacific Northwest Crop Sources of Biofuels

DOUG YOUNG, SCHOOL OF ECONOMIC SCIENCES, WSU

The PNW is recognized for its high quality apples, potatoes, grains and wine grapes. The region produces little field corn for ethanol. The most likely crop feedstocks for biofuels in the region are oilseeds for biodiesel and sugarbeets for ethanol. However, as shown by the benchmark agricultural census data in Tables 1 and 2, Idaho, Oregon, and Washington accounted for only 5 to 7 percent of national oilseed production in the two most recent censuses. USDA surveys since 2002 do not show large acreage growth. Furthermore, U.S. canola and mustard production is 1% of world production and only 7% of Canada's. While PNW average canola yields at 1,300 to 1,400 lbs/ac are higher than national levels due to more irrigated acreage, they are still well below optimistic projections by some promoters of PNW biodiesel production.

Table 1. PNW Production of Canola, Mustard, Rapeseed and Flaxseed

Census Year	'000 lbs	Canola as % of PNW Oilseeds	PNW Oilseeds as % USA
1997	49,710	70	7
2002	71,223	60	5
2007	NA	NA	NA

Source: NASS-USDA, Agricultural Census. 2007 Census data available in 2009.

Table 2. PNW Canola Production Data by State

State/Region	Production as % USA	Yield Lbs/Ac	% Ac Irrigated
Idaho	1.7	1,418	21
Oregon	0.6	1,320	18
Washington	1.3	1,345	29
USA	100	1,194	2

Source: NASS-USDA, Agricultural Census, Av. of 1997 and 2002

PNW field corn production in 2007 represented only 0.3 percent of the national total. Large PNW ethanol plants import midwestern corn. On the other hand, 18.6 percent of the nation's sugar beets were produced in the PNW in 2007, nearly all of that in Idaho. Most biodiesel plants in the region are currently operating with imported soy from the Midwest, canola from Canada, or with recycled fats and cooking oils. Projections show that meeting the 2% biodiesel blend mandate in Washington State would require the state to increase its canola production by up to twenty times. This is not likely given recent profitable alternative uses of cropland for wheat and other crops. Nonetheless, canola and other oilseeds could occupy a rotational niche in some subregions. This production could make a modest contribution to the PNW fuel portfolio. Cellulosic sources of biofuels could be promising in the long run.

A Rising Price Tide Has Raised All Commodities, but Winter Canola Still Nets Less than Soft White Winter Wheat in the Irrigated Columbia Basin

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Both winter wheat and winter canola could serve as useful rotation crops with potatoes or other high value crops in the irrigated Columbia Basin. Interest in canola has grown as a potential biodiesel feedstock recently. As shown in Table 1, prices and production costs for both crops have accelerated rapidly over 2006-2008. However, at conservative mid-summer prices, wheat had a profit advantage ranging from \$104 to \$198 per acre over the

Table 1. Profit/Ac for Alternative Irrigated Crops in the Columbia Basin by Year

Crop Year	Price	Yield	Revenue \$/ac	Cost \$/ac	Profit \$/ac
Winter Canola	\$/lb	lbs/ac			
Aug. 2006	0.0878	3200	281	388	-107
Aug. 2007	0.1307	3200	418	472	- 54
Aug. 2008	0.2480	3200	794	622	172
Winter Wheat	\$/bu	bu/ac			
Aug. 2006	3.43	120	412	415	- 3
Aug. 2007	5.98	120	718	574	144
Aug. 2008	8.60	120	1,032	734	298

Note: Aug. 1 prices for 2006 and 2007 are the USDA posted prices for Adams County, WA. The prices for 2008 are the listed August offers by Union Elevator in Lind, Adams County. Yields and total production costs are estimates based on interviews with local producers.

three year period. Canola had significant losses of \$107 and \$54 per acre in 2006 and 2007. Both crops project healthy profit margins for 2008 and the profit disadvantage for canola narrowed somewhat due to strong contract prices. If growers had been fortunate enough to market their 2007 wheat crop at the price peak of \$15/bu in mid-January they could have netted much more, but it is not prudent to base long run crop profit comparisons on short-lived price spikes. Over 2006 to 2008 canola and wheat prices increased by 182% and 151%, respectively.

With higher priced energy and other resources pushing farm input prices up, and higher crop prices stimulating demand for these inputs, it is not surprising that estimated production costs also climbed vigorously over the two years, 60% for irrigated winter canola and 77% for irrigated winter wheat. Of course each grower's actual production costs and revenues and prices will vary depending on his or her input purchasing and crop marketing strategies. Yields also vary by rotations, agro-climatic conditions and management. Overall, however, it is clear that farm level profitability has experienced one of its more vigorous historic improvements over the past two years, in the Columbia Basin and in other grain growing regions.

WSU Jumps into the Biofuel Mania?

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In 2006 the Washington Legislature jumped head-first into biofuel mania through the establishment of the Energy Freedom Program which authorized \$17 million to support the construction of biofuel processing facilities in the state and a Renewable Fuels Standard that mandated all on-road fuel in the state contain at least 2% biodiesel or ethanol. By late 2006 it became obvious that kick-starting a biofuel industry in the state would also require an investment in developing the biomass feedstocks that can be processed into biodiesel or ethanol.

In the 2007 legislative session, WSU submitted a joint request with the Washington State Department of Agriculture to fund a \$2 million (per biennium) initiative for "near-term research" to support the development of a biofuel industry in the state. Part of this funding is now supporting a state-wide investment in biofuel cropping systems research, including region-specific variety trials and agronomic research that will be on display at the PCFS, Lind and Wilke Field Days in 2008. The remainder of the funding is being used to support research on biofuel co-product development (such as Brassica Seed Meal products) and advancements in anaerobic digestion technology.

Implementation of the Washington Climate Advisory Team Agriculture Strategies

CHAD KRUGER, CENTER FOR SUSTAINING AGRICULTURE AND NATURAL RESOURCES, WSU

In early 2008, the Washington State Climate Advisory Team submitted recommendation for seven "agriculture greenhouse gas mitigation" strategies to the Governor as part of their recommended state climate change policy actions. Several of these strategies are directly related to biofuel feedstock production and conservation-based farming systems in the dryland region, including AW-2 Biofuel Feedstocks, AW-4 Ag Carbon Management, AW-5 Ag Nutrient Management, and AW-6 Ag Energy Efficiency. The goal of the Climate Advisory Team in 2008 is to provide recommendations on how Washington "agricultural lands and practices may participate voluntarily as an offset or other credit program in the regional multi-sector market-based system," of the Western Climate Initiative. A team of WSU scientists will provide technical support in 2008 to a working group of producers, agency and NGO personnel that will:

1. Complete an analysis of the existing soil carbon datasets available for a range of production systems in the state.
2. Augment the existing datasets with targeted field sampling.
3. Use this additional data and analyses to refine calibration of existing soil carbon / nitrogen models to complete a set of baseline GHG emissions scenarios for various "agricultural management systems" currently and potentially practiced in Washington State, including biofuel crops. These simulations will provide the "defensible carbon mitigating calculations" for a carbon market mechanism.

4. Complete an economic assessment of the costs of various “agricultural management systems” that will provide an assessment of the real additional costs / savings farmers incur by making a shift to a “climate-friendly” practice.
5. Complete an analysis of a set of complimentary public policy incentives that are likely to spur adoption.
6. Submit a final report to the Climate Advisory Team.

Agronomic Management of Canola

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A handful of growers have produced winter canola (WC) in the non-irrigated low to intermediate rainfall zones of the Pacific Northwest with inconsistent yields but occasionally surpassing 2000 lbs/A. Stand establishment is often not uniform and requires replanting in the fall or spring. The optimum seeding date and rate of WC and their effects on seed, oil, and meal quality is unknown in this region. In addition, new planting methodologies need to be developed to improve stand establishment and seedling survival. In the fall of 2007, preliminary experiments were initiated at Ralston (11.5 in annual precipitation) and in the foothills of the Okanogan Highlands (10 to 14 in annual precipitation) to determine the optimal seeding date, rate, and planting method for WC to improve stand establishment, crop yield and quality, and profitability. Seeding dates were August 12, 19, and 26 at Ralston and August 21 and September 4 at Okanogan. Seeding rates were 2, 4, and 6 lbs/A. A modified John Deer HZ deep furrow drill was used at both locations. The modifications to the drill included a grass-seed box for accurate seeding rates, 13 to 15-in shovels to move dry soil, and 55-lb packer wheels to improve seed-to-soil contact. During the three seeding dates at Ralston and the first seeding date at Okanogan, three of the four rows were set at normal depth ($\frac{1}{2}$ to $\frac{3}{4}$ in into moisture) and the seed failed to emerge. However, the fourth row was set to plant shallower (less than $\frac{1}{2}$ in into moisture). These seeds emerged, established, and the plants appeared to have sufficient size for overwintering. At the second seeding date at Okanogan, the shallower seeding depth was used for all rows and considerably more plants emerged and established. Plants were counted in rows/treatments where sufficient plants emerged. A spring follow-up count revealed that most of the plants survived the winter at both sites, including plants thought to be too small to over winter. Plots will be harvested in the fall and seed, oil, and meal (for feed) quality will be determined.



Early spring photo of winter canola planted (6 lbs/A) September 4, 2007 at Okanogan.



Close up of the prototype drill.

Winter Canola and Camelina Variety Testing Trials

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Canola and camelina have good potential as rotation crops for wheat in Eastern Washington. Stand establishment of winter canola can be difficult, especially when emerging through hot surface soils or following emergence with hot air temperatures. To examine the adaptation of winter canola varieties to various production regions, we are testing varieties from both local and international breeding programs in multiple cropping systems. We planted 64 winter canola varieties, including all those entered in the National Winter Canola Variety Trials, at Othello (irrigated), Ralston (summer fallow), Reardan (direct seeded on chem fallow), and Pullman (direct seeded into spring wheat stubble). Good stands were easily established with most varieties at Othello and Reardan, where planting depth was shallow and moisture was plentiful. Alternatively, none of the varieties emerged well through the deep summer fallow tillage mulch with limited soil moisture at Ralston. The Pullman site was planted after spring wheat harvest into dry soil and did not germinate until after October 3 when the first significant rain occurred. A hard frost on October 20 killed the seedlings of all the varieties in the trial. Altering furrow depths and residue levels did not noticeably increase seedling survival at this site.

Spring or fall planted camelina has advantages over winter canola in stand establishment. Available varieties are typically spring planted, but fall plantings of experimental lines at Pullman and Lind were not damaged by early frosts or winter temperatures. Spring plantings can be drilled in like canola if planted shallow ~1/2' or broadcast in late winter or early spring. Yield potential is not as high as winter canola in high rainfall regions but preliminary data suggest camelina may perform well in lower rainfall environments. Yields of ~1400 lbs/acre were achieved with several varieties at Ralston when planted in the spring after a previous spring wheat crop. A trial to compare 18 spring varieties has been planted at Lind, Lacrosse and Pullman in 2008.

Winter Canola as a Rotation Crop in the Low and Intermediate Precipitation Zones

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Multiple-year experiments are being conducted in the low and intermediate precipitation regions to document the rotation benefits of winter canola (WC) in wheat-based cropping systems. Farmers in both the low and intermediate precipitation zones have reported economically viable winter canola yields. In addition, some farmers have reported that the winter wheat (WW) crop following winter canola often has less disease and weed pressure and produces considerably higher grain yield compared to monoculture winter wheat in the traditional 2-year WW-summer fallow (SF) rotation or spring cereal (either wheat or barley) in the 3-year WW-SW-SF rotation. Additionally, it has been observed that water runoff from frozen agricultural soils does not occur following a winter canola crop, presumably because the deep tap root provides open channels for water to penetrate through the frozen surface soil layer. Neither the boost in subsequent wheat grain yield or the soil physical, biological, or pathological factors, that may account for better water infiltration and increased wheat yield as affected by having winter canola in the



Replicated strips of winter canola and winter wheat at the Ritzville study site located on the Ron Jirava farm.

crop rotation have been documented. In the low-precipitation zone on Ron Jirava's farm near Ritzville, we are comparing the 2-year WW-SF rotation to a 4-year WC-SF-WW-SF rotation. In the intermediate precipitation zone on Hal Johnson's farm near Davenport, a 3-year WC-spring wheat (SW)-SF rotation is compared to WW-SW-SF. We will determine the effects of having winter canola in the rotation on soil microbial changes, water infiltration into frozen soils, plant health of the wheat crop following winter canola, winter wheat grain yield, and farm economics compared to checks (i.e., rotations without WC in the rotation). The scientists involved in this study are a research agronomist, soil microbiologist, plant pathologist, and agricultural economist. Three rotational years of data will be obtained from each site.

Camelina Agronomy Research in the Pacific Northwest

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Passage of the renewable fuel standard for biodiesel in the State of Washington has heightened the need to significantly increase oilseed acreage in the region. Camelina (*Camelina sativa*) is a broadleaf crop in the mustard family that can be sown at low seeding rate, is competitive with weeds, and has a modest requirement for nitrogen and water. A 3-year experiment was initiated in 2007 at four sites in Washington, Idaho, and Oregon to evaluate camelina varieties, seeding rates, planting dates, planting methods, and nitrogen rates. The goal of the research is to develop agronomic practices to incorporate camelina into PNW crop production systems and assist the fledgling oilseed industry to understand and utilize this crop. We have selected representative areas in the PNW that include all the major cropping systems throughout the region. Sites are: (i) Lind, WA, (ii) Pendleton, OR, (iii) Moscow, ID, and (iv) Corvallis, OR, where average annual precipitation is 9.5, 16, 24, and 40 inches, respectively. These four sites represent all the major cropping zones in the PNW. Specific procedures and experimental designs are consistently used at all sites. Although preliminary studies show potential adaptability of camelina, there is not yet sufficient information to provide general crop production practices or indicate the geographic adaptability of the crop. Limited work in Montana and North Dakota suggests that camelina has potential in marginal production areas with low precipitation and shallow soils. This research project will be shown and discussed at the major university field days in 2008 at Lind, Pendleton, Moscow, and Corvallis.



Farmers, agricultural industry personnel, government officials, and the general public learn about camelina at the 2007 Lind Field Day.

Camelina Cropping Systems Research at Lind

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A 6-year dryland cropping systems experiment was initiated at the WSU Dryland Research Station October 2007 to evaluate camelina in wheat-based systems. Camelina is a Brassica oilseed crop that has shown good potential in low-precipitation regions in the Northern Great Plains and (with limited testing) in the Pacific Northwest. The cropping systems experiment will test the feasibility of a 3-year winter wheat-camelina-summer fallow rotation versus the standard 2-year winter wheat-summer fallow rotation. Experimental design is a randomized complete

block with four replications. Individual plots are 30 ft wide x 250 ft long. All phases of both crop rotations are present every year (total of 20 plots). Camelina is broadcast directly into winter wheat stubble in October with an air drill and lightly pressed into the soil with an attached coil packer (Fig. 1). Of critical concern is whether we can maintain adequate surface residue during fallow after camelina to protect the soil from wind erosion. Therefore, the undercutter conservation tillage method for non-inversion primary spring tillage plus aqua nitrogen fertilizer delivery is used to optimize surface residue retention. Measurements include soil water use, weed ecology, surface residue, grain yield and, ultimately, farm economics. The WSU Biofuels Initiative provided funding to start this project.



Fig. 1. An air drill is used to broadcast camelina seed on the soil surface followed by a coil packer to press the seed into the soil.

Developing Weed Control Methods for Biofuel Crops

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Increased interest in biofuel production in the state of Washington has led to state funding for the development of biofuel crops. However, adaptability of these crops to eastern Washington is somewhat lacking. The most common oil seed crops grown in the U.S. in 2005 included soybean (72 million acres) cottonseed (14 million), sunflower (2.7 million), peanut (1.6 million) canola (1.2 million), flax (1 million), and safflower (169,000). Unfortunately, the oilseed crops with the greatest potential for adaptability to eastern Washington production are those with the fewest acres nationally. Not surprisingly, these minor crops have few to no pesticides labeled for use in their production. Current and previous WSU research into minor oilseed crops has focused on the development of herbicides and other weed management practices for their production. Recent research on weed control for oilseed crops has included work on meadow foam, safflower, yellow mustard, canola, and sunflower. Specific studies in eastern Washington are:

Safflower: Since 1998, herbicide evaluation was done at Ritzville and Lind WA. Efficacy and crop safety studies identified the value of labeled herbicides and potentially labeled herbicides as candidates for InterRegional-4 or other labeling programs. These include herbicides which are effective in controlling grass species or particularly troublesome broadleaf weeds such as Russian thistle.

Yellow Mustard and Canola: Also since 1998, herbicides have been evaluated for potential labeling in these commodities. Generally, yellow mustard appears to be agronomically the best suited crop in eastern Washington. Research on weed management programs in winter and spring canola has included both single component and systems work. Currently, canola has a greater number of labeled pesticides than other brassica crops. Moreover, herbicide resistant (Roundup Ready, LibertyLink, and Clearfield) varieties of canola are available. Herbicide-resistant varieties have been an important part of much of the systems research currently underway.

Canola and Camelina Fertility: Review of Literature and Initiation of New Studies

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A review of existing literature reveals that canola generally requires more nitrogen, phosphorus, potassium, and sulfur per unit of yield than cereals such as wheat or barley. Due in part to a low harvest index (proportion of aboveground plant dry matter that is seed) and high nutrient concentration in the residue, canola also leaves more nutrients in the field after harvest than comparable yields of cereals. Cycling of nutrients in this residue to subsequent crops is one important rotational benefit of canola. Fertilizer rates for canola are a function of residual soil nutrient levels and the yield potential of the site. For optimum yields, canola requires approximately 6 to 8

lbs of N supply (fertilizer+soil sources) per 100 lbs expected seed yield. Phosphorus, potassium, and sulfur recommendations can be based on soil test levels with interpretations similar to those of cereals. Canola has a lower tolerance of seed-placed starter fertilizers than cereals so rates of nitrogen+potassium should not exceed 5 lb/acre.

There are several unknowns regarding canola fertility. In existing literature, nitrogen recommendations for canola are quite variable, ranging from 4 to 11 lbs nitrogen supply per 100 lb seed yield. There is also debate over the optimum timing of nitrogen application for winter canola to ensure high yields but minimize the potential for winterkill. Optimal placement of banded fertilizer at planting and canola root responses to banded fertilizer is poorly understood. Relatively little is known about how fertility management affects oil yield and quality in canola since the majority of studies assess only management effects on seed yield. Finally, very little is known about camelina nutrient requirements to optimize oil yield.

This project involves a series of experiments designed to assess canola and camelina seed and oil yield responses to nutrient rates and application timing. Studies are located near Prosser, Davenport and Pullman, WA. Winter canola studies were initiated at each location in fall 2007. Spring canola and camelina studies are planned for 2008 at Davenport and Pullman. Treatments include nitrogen and sulfur rates, fall-spring nitrogen application timing, and phosphorus rate responses. In fall 2007, winter canola failed to establish at Pullman due to inadequate seed zone moisture. Establishment was spotty at Davenport. Fall establishment of winter canola is a major challenge that will have to be overcome in order for this crop to be successfully grown in dryland environments.

Links to other extension resources on canola fertility:

Ontario, Canada: <http://www.omafra.gov.on.ca/english/crops/pub811/8fert.htm#table81>

Great Plains, U.S.: <http://www.oznet.ksu.edu/library/crpsl2/mf2734.pdf>

North Dakota: <http://www.ag.ndsu.edu/pubs/plantsci/soilfert/sf1122w.htm>

Montana: <http://landresources.montana.edu/FertilizerFacts>

Oregon State University: <http://extension.oregonstate.edu/catalog/pdf/em/em8943-e.pdf>

Management of Rhizoctonia Damping-off of *Brassica* Oilseed Crops in the PNW

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Rhizoctonia solani can cause pre and post-emergence damping off of *Brassica* oilseed species with adverse effects on stand establishment. In greenhouse experiments, we have examined resistance to two groups (AGs) of *Rhizoctonia solani* among various *Brassica* species and varieties. *R. solani* AG 2-1 is among the most virulent strains and can drastically reduce seedling emergence. *R. solani* AG 8 can cause seedling stunting and also infects wheat. A few *B. napus* canola varieties appeared more tolerant to both groups of the pathogen in greenhouse experiments. The hybrid cultivars Flash and Sitro, from the German company DSV, and the open-pollinated DeKalb variety CWH687 showed the best tolerance to the two *Rhizoctonia* groups. Camelina was similar in susceptibility to most canola varieties, as were yellow, brown and Ethiopian mustards. We have examined various chemical seed treatments on the incidence of seedling damping-off of canola in the greenhouse, inoculated with *R. solani* AG 2-1. We found the seed treatments to be mostly ineffective. Since the pathogen attacks the young hypocotyls, these tissues were not protected by non-systemic seed treatments. We are now developing assays to determine if the differences in greenhouse resistance among the canola varieties can be observed in the field.

Tall Wheatgrass Feedstock Evaluation

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Only a handful of grasses grow in Washington that produce enough biomass volume to warrant biofuel attention. Switchgrass has received the lion's share of the attention because it produces large volumes of biomass that can be

converted to ethanol. Unfortunately, switchgrass does not grow well in most of Washington without irrigation. Tall wheatgrass on the other hand has been grown in dryland sites of Washington for over 50 years. It also occurs throughout the Great Plains, western states and Canadian Prairie provinces. This widely adapted grass produces as much as 7 tons of biomass per acre. It is far from an ideal pasture/hay grass, but its biofuel potential is intriguing.

Tall wheatgrass stems make up a large percentage of the total biomass. Stems are mainly composed of cellulose and lignin, and the leaves have less of these structural carbohydrates. Structural carbohydrates are not optimal for ethanol production so ethanol production from tall wheatgrass might not be economical. However, gasification and direct combustion of tall wheatgrass are definite possibilities.

Gasification of tall wheatgrass feedstock involves heating the biomass in order to convert the material into combustible syngas. The syngas can be cleanly burned to produce heat or generate electricity. This process is in operation in Scandinavia. Direct combustion involves burning bales, pellets, or finely chopped feedstock. Direct combustion might be an option for rural people looking to reduce their reliance on natural gas and/or electricity to heat farm buildings and homes.

The Pullman Plant Materials Center in cooperation with WSU established a study at the Prosser Irrigation Agriculture Research and Extension Center to compare 4 tall wheatgrass varieties. One of the varieties, Szarvasi I, is a Hungarian line specifically developed for the European biofuel market. The Prosser data indicate that Szarvasi I is no better than the pasture/hay varieties currently being grown in North America. Plant Materials Centers in several western states are installing similar studies to determine if there are regional differences in yield, energy output, and plant adaptation.

Biofuel Feedstock Research in Irrigated Central Washington

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The biofuel feedstock trials and the search for better crops in our cropping system have been in our program since 2004 under irrigation of central Washington. Most of the temperate and sub tropical crops have been included in our trials from oil producing crops camelina, canola/rapeseed, crambe, mustard, safflower, soybean and sunflower to biomass crops as switchgrass for cellulosic ethanol. Camelina, a short growing season oilseed, belongs to the same family with canola and mustard which can be produced on marginal land with low energy input and is a short growing season crops. Camelina oil is a source of high quality oil with over 30% Omega-3 fatty acid and second to flax oil. Canola both spring and winter species can be produced well in Washington. Winter canola requires 10 months to mature and its yield doubled spring grown canola. Mustard is another *Brassica* species which tolerates more harsh weather and low soil nutrient. Safflower produces well in Washington and uses less water than soybean and can produce high yield and high oil concentration. Safflower and winter canola can produce 1700 to 2500 lbs oil per acre. Soybean with maturity groups 000, 00, 0 can be grown in Washington and produced from 2950 to 3900 lbs per acre on sandy soil if enough irrigation is applied. Switchgrass is a perennial warm-season grass produces high biomass yield after the establishment year. Under irrigation we produce two harvestable biomass harvests per growing season. The first biomass harvest is taken in early July and the final in early October. Switchgrass is photoperiod sensitive with early maturing cultivars transitioning into winter dormancy earlier than later maturing cultivars. If allowed to transition into dormancy in the fall, we have not experienced winterkill problems in our environment and under our agronomic management practices.

Camelina Production in Irrigated Central Washington

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Camelina (*Camelina sativa* L.) is an ancient crop and is a native of northern Europe from Finland to Romania and east to Ural Mountains. Camelina is grown for its oil used as lamp oil, medicinal treatment and as an edible oil. It belongs to a large mustard family (Brassicaceae) like canola, rapeseed and vegetable mustard green and mustard seed. It is grown in marginal agriculture lands with low fertilizer and low soil moisture. Camelina is a short

growing season oilseed that matures in 80 days. It produces about 35% oil containing high Omega 3 fatty acids (34 to 36%). Camelina seed is light to bright yellow and very small (about 345,000/lb). Camelina has good agronomic characteristics. It is easy to grow and is low in input requirements (water, nutrients and pesticides). It can be broadcasted. Its oil is more stable than most of the Omega 3 fatty acids producing crops as flax, hemp and perilla.



Camelina at full pod set (~70 days after planting).

Thirty eight commercial and experimental lines of camelina were planted in Othello. Trifluralin (Treflan) was incorporated on the top 4 inches at the rate of 1 qt/a during seed bed preparation. Fertilizers were added to the experimental plot to 100 lbs N and 50 lbs P₂O₅ per acre. Yields ranged from 1790 lbs/a (BS 74) to 2745 lbs/a (cv. Robbie). Camelina can germinate on saline soil (780 ppm Na or 1.2 mmho/cm) set blooms but most of the flowers were aborted. Camelina was not tolerated Stinger (clopyralid) using to control nightshade as for canola/rapeseed. Stinger aborted camelina flowers, pods were deformed and seeds were not developed.

There are few winter camelina lines that can tolerate cold weather like winter canola. There is no information available about winter camelina in Washington. Research needs to be done to obtain information about its adaptation to Washington.

Arundo donax for Biomass Ethanol, Fiber, Carbon Sequestration

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Arundo donax is one of the highest cellulosic biomass producing plant species known, clearly capable of producing more shoot biomass per acre under irrigation than forage grasses, switchgrass, cereal straws and hybrid poplar (Fig. 1). *Arundo* has a perennial growth habit, does not produce seed under temperate growing conditions, but reproduces vegetatively from apical internodes and root corms. *Arundo* is an invasive weed in many areas of the U.S. such as California and the Southern U.S., particularly where it was introduced to control erosion along stream banks. Nevertheless, it has been successfully cultivated and controlled on arable upland plantations for woodwind reed production. Available herbicides such as glyphosate can effectively control *Arundo*. *Arundo* is a unique C₃ plant that is capable of maintaining higher photosynthetic rates than some C₄ plants. *Arundo* forms an equally impressive below ground root biomass that can potentially increase soil C sequestration. Initial baseline data on cellulose, lignin, hemicelluloses and ash composition, and biomass yields in south Columbia Basin have been collected. Based on these results and initial papermaking pilots conducted at UW, *Arundo* is a very appealing pulp fiber source for the PNW paper industry.

Two stands of *Arundo donax* have been established at Prosser WA. The first stand of 63 ft x 81 ft was established in March 2003 with stems and rhizomes collected from California. It was observed that a much higher percentage of rhizomes sprouted compared to the stems. A second larger stand (160 ft x 160 ft) was established in May 2006 using all rhizomes from California. Incomplete stand establishment was due to the presence of non-viable rhizomes and the late planting date. Transplants were made into these areas in an attempt to fill in the stand. This second stand was set up to establish plots for examining planting density, water and nutrient variables, as well as herbicide control treatments. The 2006 planting was established with two in row spacings (18 and 36 inches). In 2007, two irrigation regimes were imposed with half of the plots receiving replacement irrigation at 100% and half receiving 66% of replacement. First year yields have ranged from 2 to 11 tons/acre, second year

yields have ranged 12 to 22 tons/acre, third year 15 to 25 tons/acre. *Arundo* stands remain intact through harsh winter conditions, and when harvested, will re-grow in the spring.

Future research will examine the physiological and genetic basis for its extraordinary biomass yields, and whether these traits are transferrable to other crop species. We will be watching for potential pathogens and insects in long term plantations. Thus far, we have observed little susceptibility in small plots of young plantations, increased pest pressures are likely in older and more widespread plantations. We will define proper agronomic management practices, and evaluate *Arundo* for potential carbon crediting for carbon sequestration.

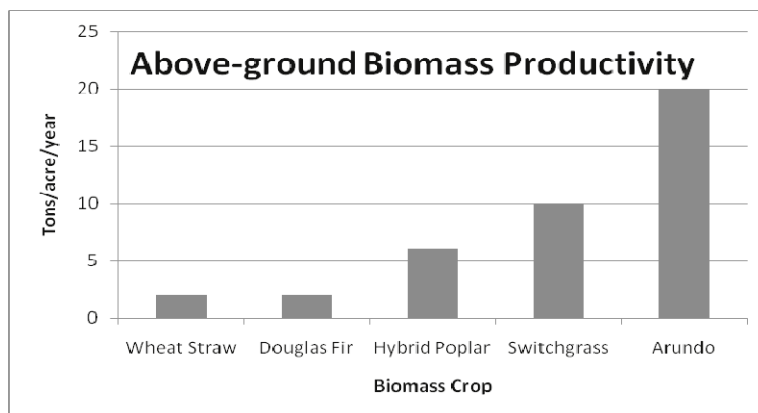


Figure 1. Above-ground biomass productivity of major cellulosic crops.

Part 2. Breeding, Genetic Improvement, and Variety Evaluation

Winter Wheat Breeding, Genetics and Cytology

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Xerpha (WA007973) SWW was approved for variety release in February of 2008. It is a selection from a cross of Eltan and Estica made in 1999. A greenhouse breeding technique called single-seed descent was used to rapidly advance this line in the greenhouse to its fifth generation in just two years. Subsequent field selection was based on yield, test weight, disease resistance, quality and general agronomics.

Xerpha is unique in that it has a very broad range of adaptation. It has been the top yielding variety in every precipitation zone for 2006 and 2007 in the WSU Extension Uniform Cereal Variety Testing Program where it was compared with 49 other varieties, breeding lines, and varietal blends from 10 other programs at 19 locations. It also performed extremely well in 2007 N. California, S. Idaho, and Oregon variety testing programs.

The 2007 WSU Variety Testing summarized HRW statewide yield results show WA007976, WA008023 and Bauermeister ranked as first, second and fourth, respectively. There were over 90,000 acres of Bauermeister produced in WA in its first year of commercial production.



'Xerpha' is named in honor of Xerpha Gaines, WSU botanist.

USDA-ARS Club Wheat Breeding

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Club wheat acreage increased to 173,400 acres in WA in 2007. Approximately 300 crosses were made to incorporate new sources of resistance to stripe rust into spring and winter breeding lines. We also developed winter and spring wheat populations to study the inheritance of stripe rust resistance. In the breeding program our crosses were to create populations with resistance to barley yellow dwarf virus resistance, cold tolerance, Cephalosporium stripe, Fusarium crown rot and pre-harvest sprouting. Marker assisted selection is used routinely to select for resistance to stripe rust, barley yellow dwarf virus resistance, Hessian fly and strawbreaker foot rot. We evaluated over 45,203 winter wheat plots and head rows in 11 locations in WA, ID, and OR in 2007, similar to previous years. We added a new location at the Richard Pfaff farm at Farmington, WA. We continued to increase our spring wheat breeding effort, specifically to introgress new sources of stripe rust resistance into spring wheat. For 2008, four breeding lines were entered into the Washington State Cereal Variety trials, the club wheats, ARS970278-2, ARS970075-3C, ARS970168-2C, and the soft white wheat ARS960277L. ARS970279-2 is tall, ARS97075-3C has high test weight, and ARS970168-2C is short relative to current cultivars. ARS970168C and ARS960277L both had yields that were greater than Eltan, Chukar, and Tubbs at our testing locations while yields of the other two lines were comparable to Tubbs. We have made significant progress in breeding earlier maturing high yielding club wheat breeding lines with the traditional excellent club wheat quality.

Improving Spring Wheat Varieties for the Pacific Northwest

KIMBERLEE KIDWELL, GARY SHELTON, VIC DEMACON, AND ARRON CARTER, DEPARTMENT OF CROP AND SOIL SCIENCES, WSU

Louise was grown on more than 70,000 acres in 2007, representing 37% of the total soft white common spring (SWS) wheat acreage. Louise has superior high-temperature, adult-plant (HTAP) resistance compared to Alpowa, is partially resistant (65%) to the Hessian fly (HF), and has better emergence than both Zak and Alpowa. The grain yields of Louise equaled or exceeded most varieties in the majority of field trial evaluations conducted from 2001 to 2007. The end-use quality of Louise is superior to Zak, and a dramatic end-use quality improvement compared to Alpowa. Our new SWS variety, Whit (WA8008), was released in March 2008 and has many of the same agronomic and end-use quality attributes as Louise, and also matures earlier, is shorter in height and has higher test weight. Whit is HF resistant, has moderate levels of HTAP resistance, excellent end-use quality and is targeted to the high rainfall zone. Two additional lines, WA8039 (SWS) and WA8047 (spring club), were approved for Breeder seed increase in 2008. Both are broadly adapted and will be targeted to the intermediate to high rainfall production zones.

Our hard red spring (HRS) variety Tara 2002, has been grown on more than 51,000 acres since 2003 in Washington State. The unique quality attributes of Tara 2002 resulted in the development of an identity preserved market for this variety. Tara 2002 is used in a flour blend called The Shepherd's Grain, which is sold by Columbia Plateau Producers to local and regional clientele including WSU Dining Services. Our new HRS line Kelse, was released in March 2008 and has many essential characteristics of a successful direct seeded HRS variety in the intermediate to high rainfall zones and is targeted to replace WestBred 926. Kelse is HF resistant, has moderate levels of HTAP resistance, and has excellent end-use quality. The yield potential of Kelse equals or exceeds that of WestBred 926, and grain protein content averages for Kelse are higher than those of WestBred 926.

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

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Winter injury and cold tolerance are some common risk factors associated with winter wheat production in the Pacific Northwest. An artificial freeze experiment was designed and implemented to test these variables due to

the large variation of freezing temperatures, soil conditions, snow pack, and plant growth stages in PNW breeding nurseries and production fields. The tests are performed in the Plant Growth Center at WSU, employing the use of a programmable freeze chamber allowing for a tightly controlled environment. The experiment is designed to test plants in uniform soil conditions and plant growth stages under two different temperature regimes, -10C and -12C respectively. The lines are grown for nine days, vernalized for six weeks, and then exposed to a 24 hour freeze cycle. Every two minutes during the freeze cycle, exact soil temperatures are collected from the roots of each set of plants using temperature probes connected to data collection software. After the freeze test, the plants are grown at standard greenhouse temperatures. Regrowth is rated after two to three weeks and reported as a survival percentage. The values are called Lethal Temperature at 50% (LT-50) values. These LT-50 values are examined and compared with the LT-50 values of other cultivars with similar traits, to single out genes within the plant that are contributing to the resistance of cold, disease, or other factors that attack winter wheat. The LT-50 values have shown good correlation with winter survival over the past five years of observations in the WSU winter wheat variety trials at Spillman Agronomy Farm and other locations throughout WA. Most of these plants being tested are already segregated into regional spring and winter lines, elite lines, and genetic (significant in relation) mapping populations. By doing this, it makes it easier to see the relationships of the LT-50 values, apply their possible significance, and discover the genetic material that will be responsible for future crop improvement. The ultimate goal of these investigations, therefore; is to increase and stabilize our yields through resistance to cold, disease, and other crop loss.

The Effect of Wheat ABA Response Mutants on Grain Dormancy and Drought Tolerance

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Yield of wheat grown in the Pacific Northwest is often negatively influenced by drought. The plant hormone abscisic acid (ABA) is responsible for the induction and maintenance of seed dormancy and responses to abiotic stress. We have isolated 25 wheat mutants in three spring wheat backgrounds that are more sensitive to inhibition of germination by ABA. We hypothesize that these mutants may have increased tolerance to drought as well as an increase in seed dormancy. Drought tolerance and sensitivity to ABA have been measured using several methods. The rate of water loss from both mutant and wild type plants has been compared under drought stress conditions under controlled water-limited conditions in the Wheat Plant Growth Facility, and in field experiments at Central Ferry and Lind WA, to determine if mutants show a slower rate of transpiration. At least three mutants appear to lose water more slowly than the wild type and have an increased ability to survive a period of drought stress in the greenhouse. Vegetative sensitivity to ABA as measured by stomatal closure has been measured using two approaches: direct measurement of stomatal aperture after ABA application to leaves, and measurement of transpiration rate of individual excised leaves placed in ABA solution of varying concentrations. Carbon isotope discrimination has also been measured over three years. Carbon isotope discrimination is an indicator of transpiration efficiency, which is a measure of the carbon fixed per unit water transpired. Mutants with decreased stomatal aperture due to increased ABA sensitivity are expected to show a decrease in carbon isotope discrimination. Rankings of individual mutants over three years are consistent, with one mutant exhibiting significantly lower carbon isotope discrimination than the wild type. Finally, initial determinations of yield in the greenhouse and field show that there is no yield penalty associated with these mutations under relatively non-stressed conditions. Future work will focus on the effect of these mutations on pre-harvest sprouting resistance.

Application of Biotechnology to Spring Wheat Variety Improvement

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Biotechnology is useful for identifying superior breeding lines in early generations of selection that carry genes 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 incorporate *Yr5* and *Yr15*, two seedling resistance genes to stripe rust that have not been circumvented by any race of the pathogen found in North America to date, into Scarlet (HRS), WA7900 (HWS), Zak (SWS) and Alpowa (SWS). In 2008, Scarlet backcross derivative WA8034, which carries both *Yr5* and *Yr15* in the homozygous state, was proposed for pre-release as 'Scarlet-09'. This is the first MAS derived spring wheat cultivar from our program to reach this stage of development. Two Zak, two Scarlet and two WA7900 backcross derived-lines were confirmed to carry both *Yr5* and *Yr15* in the homozygous state. These lines are promising candidates for variety release since they are expected to have durable resistance to stripe rust and will be evaluated in 2008 field trials. A high grain protein content gene, *Gpc-B1* from the hard red spring wheat variety 'Glupro', was incorporated into Scarlet, Tara 2002, and the hard red winter line WA7869 using MAS. WA7975, a backcross derivative of WA7869, which carries *Gpc-B1* was released as 'Farnum' in March 2008. It is a tall, late maturing hard red winter wheat that was released in collaboration with Drs. Kim Campbell and Steve Jones. 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 2008. We also successfully introgressed the 2+12 glutenin profile and HTAP into an Eden (spring club) background through seed storage protein profile-assisted selection and yield trials will be evaluated in the field in 2008.

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

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A primary goal of most public wheat breeding programs is to implement marker assisted selection (MAS) for useful complex traits. U.S. wheat researchers have developed protocols for more than fifty molecular markers for resistance genes and quality traits and have used these markers to incorporate valuable genes in the best breeding lines from ten different market classes. In Washington, the spring and USDA wheat breeding programs are introgressing genes for resistance to stripe rust, barley yellow dwarf virus resistance, resistance to Fusarium crown rot, and for high grain protein content. In addition we created a population of 188 lines from the Louise/Penawawa and identified 365 polymorphic markers on the two parents. The progeny was 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 188 lines were also planted at the Whitlow and Mt. Vernon farms for stripe rust resistance evaluation. Analysis of the 2007 stripe rust data revealed a major quantitative trait loci (QTL) for high-temperature adult-plant (HTAP) resistance on chromosome 2BS, originating from the resistant parent Louise. Molecular markers are being identified which flank this gene, allowing more efficient transmission of HTAP resistance from Louise to other elite germplasm. It also makes possible the pyramiding of multiple forms of resistance together in one cultivar, increasing the durability of the resistance. Data from 2008 trials (planted at the same 2007 locations) will help validate the 2007 stripe rust results, as well as provide more information about other important agronomic traits. Both years' data will aid in the identification of molecular markers for complex traits important in the PNW. Use of these markers in PNW wheat breeding programs will speed up the incorporation of important genes and the development of new wheat cultivars.

Genetic Characterization of Rhizoctonia Root Rot Resistance Developed Through EMS Mutation Breeding in Wheat (*Triticum aestivum* L.).

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Rhizoctonia root rot is an important soil-borne seedling disease of wheat in the Pacific Northwest (PNW) of the USA and growing resistant varieties would be the most efficient way to manage this disease. Scarlet-Rz1, a resistant genotype that we developed through EMS mutation breeding, is the first and only source of genetic

resistance to this disease identified to date in hexaploid wheat. The objectives of this study were to: (1) generate a double haploid (DH) mapping population and; (2) identify and develop DNA markers for Rhizoctonia root rot resistance gene(s) in Scarlet-Rz1. Two different DH populations of 102 and 105 lines, respectively, obtained from two independent F1s from Scarlet-Rz1 (resistant) x Scarlet-S (susceptible) were developed using microspore culture. Plant materials were evaluated for resistance levels to Rhizoctonia root rot based on numbers of lesions on infected roots counted visually using a scale of 1 to 8. Infected roots also were analyzed for length using WinRhizo software. Scarlet-Rz1 and Scarlet-S had disease scores of 1-2 and 5-6, with root lengths of 65 cm and 45 cm, respectively. Sixty of the 1116 SSR markers tested were polymorphic between the parents. The DH populations are currently being phenotyped for disease response and genotyped with the 60 polymorphic markers. Marker and disease data will be used for linkage map construction and resistance gene(s) mapping. Molecular markers identified in this study will be used in marker-assisted breeding strategies to efficiently introgress Rhizoctonia root rot resistant into wheat cultivars.

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

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Two major genes for resistance to stripe rust, *Yr5* and *Yr15*, currently provide complete resistance to all known lines of stripe rust in the US. *Yr5* and *Yr15* have been previously located on (2B and 1B, respectively). Molecular markers have been identified for both genes, but, unfortunately, those markers are frequently not polymorphic in germplasm in breeding programs from the Pacific Northwest. Our objective was to re-map the two genes using data from a combination of SSR, RGAP, and STS markers. We mapped the markers and the stripe rust resistance trait in two RIL populations, one of Avocet-*Yr5*/Avocet-Susceptible (S) and the other in Avocet-*Yr15*/Avocet-S. We mapped 11 SSR and 1 STS loci to chromosome 2B in a 26.4cM region flanking *Yr5*. A total of 8 SSR and 1 STS loci were mapped to chromosome 1B in a 5.9cM region flanking *Yr15*. Three markers, *wpg34*, *gwm413*, and *Barc8* were completely linked with *Yr15*. Currently, we are testing germplasm from various breeding programs throughout the US with different genetic backgrounds to verify the polymorphic nature of the closest linked markers (*barc167*, *barc349*, and *wmc175* for *Yr5*, *barc8* and *gwm413* for *Yr15*), based on the developed map. These maps will enable more efficient marker assisted selection of these genes with several marker choices.

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

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Quality Assessment of WSU Wheat Breeding Lines: We provide end-use quality testing of breeding lines for the WSU wheat breeding programs. With collaboration of the WWQL, we tested 1,177 breeding lines of the 2007 harvest for grain quality, milling quality, composition, biochemical properties and baking quality. The end-use quality assessment of wheat breeding lines facilitates the release of new varieties with improved marketability in addition to good agronomics.

Protein Content Potential of Wheat Growing Locations: We established a procedure for identifying growing locations in Washington State suitable for the production of wheat with required protein content. Protein content data of multiple varieties in each of seven wheat classes grown in multiple locations for five to six years were collected and used to determine protein content potential of each location. Using the protein content data, we calculated the probability of producing wheat grain with desirable protein content for each location and identified the agro-climatic zones suitable for growing each class of wheat. By growing each class of wheat in the identified agro-climatic zones, we will be able to improve our capacity to consistently produce and deliver wheat of improved end-use quality to domestic and international markets.

Protein Quality of Wheat Suitable for Making White Salted Noodles: To identify the quality of wheat protein suitable for making noodles, we determined the quantitative and qualitative roles of gluten protein on processing and product quality of white salted noodles through the incorporation of gluten isolated from wheat flours of various protein quality. Quantitative increase in gluten protein of wheat flour results in decreased water

requirement for making noodle dough and cooking loss of noodles; increases in noodle thickness, cooking time, hardness and tensile strength. Soft wheat gluten, when incorporated into noodles, increases hardness and tensile strength of cooked noodles more than hard wheat gluten.

USDA-ARS Western Wheat Quality Laboratory

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The mission of the USDA-ARS Western Wheat Quality Lab is two-fold: conduct milling, baking, and end-use quality evaluations on wheat breeding lines, and conduct research on wheat grain quality and utilization. Our web site <http://www.wsu.edu/~wwql/php/index.php> provides great access to our research. Our research publications are available on our web site. The WWQL collaborated in the development of four new wheat varieties: Xerpha (WA7973, soft white winter), Farnum (WA7975, hard red winter), Kelse (WA7954, hard red spring), and Whit (WA8008, soft white spring). Our current research projects include grain hardness, puroindolines, waxy wheat, polyphenol oxidase (PPO), arabinoxylans, SDS sedimentation test, and wheat ash. Our recent publications include studies on pilot scale milling characteristics of transgenic isolines of hard wheat over-expressing puroindolines, and the silencing of puroindoline a which alters the kernel texture in transgenic bread wheat. Hard kernel puroindoline allele near-isogenic lines in Alpowa were developed and registered. Two reviews on the molecular genetics of puroindolines and related genes were published, and an examination of the sodium dodecyl sulfate (SDS) sedimentation test for gluten strength was reported. 'Waxy•Pen' soft white spring waxy wheat and 'Bauermeister' were registered. Other studies included allelic variation of PPO genes located on chromosomes 2A and 2D and development of functional markers for the PPO genes in common wheat, PPO in wheat and wild relatives, PPO gene structure in wheat and related species, and oxidative gelation measurement and influence on soft wheat batter viscosity and quality. A device for the preparation of cereal endosperm bricks was also developed.

WSU Extension Uniform Cereal Variety Testing Program – 2007

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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 102 separate nurseries across 13 eastern Washington counties in 2007. A combined total of 187 wheat and barley varieties/experimental lines were evaluated (83 winter wheat, 10 winter barley, 58 spring wheat and 36 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 790 new lines of winter and spring wheat entered in the Variety Testing Program and (4) 25 nursery tours/field days were held in cooperation with local WSU Extension Educators and commodity groups with a total attendance of 1010 individuals.

Regional Cooperative Testing in the Western Regional Uniform Wheat Nurseries

CHRIS HOAGLAND, LESLEY MURPHY, XIANMING CHEN, CRAIG MORRIS, DEVEN SEE, AND KIMBERLY GARLAND CAMPBELL, USDA-ARS WHEAT GENETICS, QUALITY, PHYSIOLOGY AND DISEASE RESEARCH UNIT, PULLMAN, WA

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

Barley Improvement for Dryland Cropping Systems

STEVE ULLRICH, VADIM JITKOV, JUDY COCHRAN, ALICIA. DEL BLANCO, AND H.-J. LEE, DEPARTMENT OF CROP AND SOIL SCIENCES, WSU COLLABORATORS: ANDRIS KLEINHOF, DITRICH VON WETTSTEIN, JOHN BURNS, XIANMING. CHEN, TIMOTHY PAULITZ, AND BYUNG-KEE 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, 'Bob' and 'Radiant' are well adapted to the dryland growing conditions in eastern Washington. Based on results through 2007 from the State Uniform Nursery, Bob and Radiant (>100 loc.-yr) yielded 98 and 99% of Baroness, respectively. Yields were statistically equal or greater than Baroness at individual locations. The breeding line 02WA7028.9 yielded 104% of Baroness in 2007 and shows promise as a new release. Two hulless waxy lines, WA9820-98 and 01WA13860.5, are release candidates to be directed at food and feed use. Food barley demand is on the rise in part due to the FDA "Heart Healthy" endorsement. Novel trait combinations bred include hulless + waxy + proant-free for food products and hulled + waxy for grain fractionation and ethanol production. Other research involves molecular genetic mapping of dormancy, preharvest sprouting, grain hardness and malting quality genes and molecular breeding for malting barley improvement. Combining the high yield of Baroness 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.

Improving End-Use Quality Of Barley And Wheat For The Consumer

DIETRICH VON WETTSTEIN^{1,2}, GAMINI KANNANGARA¹, NII ANKRAH¹, PATRICK REISENAUER¹, ROBERT BRUEGGEMAN¹, ANDRIS KLEINHOF¹, SACHIN RUSTGI¹, KULVINDER GILL¹, GREGOR LANGEN³, KARL HEINZ KOGEL³, AND CHARLES PAUL MOEHS⁴

1. DEPARTMENT OF CROP AND SOIL SCIENCES, WSU

2. SCHOOL OF MOLECULAR BIOSCIENCES, WSU

3. RES. CENTRE FOR BIOSYSTEMS, LANDUSE, AND NUTRITION, JUSTUS LIEBIG UNIVERSITAET GIESSEN

4. ARCADIA BIOSCIENCE INC., SEATTLE, WA

Six-row barley 01NZ706 produces proanthocyanidin-free grain with high diastatic power that allows breweries to bottle brilliant clear beer without chill haze proofing with polyvinyl-pyrrolidone or the Schoenen process as is presently practiced to avoid protein precipitation in the bottle and achieve good shelf life. Under irrigation 01NZ706 has a yielding capacity of 5000 to 8000 Lbs/A i.e. 18% more than the malting standard variety Morex. In the AMBA 2007 Quality Evaluation Program it met all ideal commercial malt criteria. In the variety testing program of WSU comprising 62 sites over the years 2003-2007, line 01NZ706 yielded on an average equal to Legacy and with a significant 14% increased average yield over Morex. Evaluations of malting quality by the USDA/ARS Cereal Crops Research Unit, Madison WI have shown that line 01NZ706 in Eastern Washington with precipitation as low as 18 inches can achieve malting quality scores comparable to Morex and the Busch Agriculture Resources malting barley cvs. Legacy and Tradition.

In the project to breed wheat acceptable for celiac sprue patients and all consumers of wheat products the barley gene for DEMETER (encoding the DNA demethylating enzyme 5-methylcytosine deglycosylase) has been cloned and sequenced. This gene from barley and the three corresponding genes from the three wheat genomes are to be silenced in the endosperm by mutation in order to prevent the synthesis of the gliadin type proteins causing celiac sprue. Bioinformatic analyses have shown that the genes for these proteins in wheat like in barley are silenced by DNA methylation in the vegetative parts of the plant and de-methylated at the beginning of storage protein synthesis in the developing grain. Cloning and sequencing of the DEMETER genes from the wheat BAC (Bacterial Artificial Chromosome) library is in progress.

Financial support from grants of the US National Institutes of Health and the Deutsche Forschungsgemeinschaft is gratefully acknowledged.

Grain Legume Breeding and Genetics

GEORGE VANDEMARK, KEVIN MCPHEE, WEIDONG CHEN, JARROD PFAFF, LORNA BURNS AND SHERI 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. Significant advancement has been made in combining multiple disease resistant genes in adapted breeding lines. Several new dry pea varieties have been approved for release and 'Windham', a semi-dwarf winter feed pea, has established a prominent role for winter pea production.

The U.S. lentil industry competes in the world market and must have cultivars with acceptable quality for a variety of market classes. '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 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. '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. The most recent release is CA0090B347C and has not been named yet. This new cultivar has smaller seed than previous releases, but has improved Ascochyta blight resistance and broad adaptation with high yield potential. For more information, please refer to the Grain Legume Research Unit website at: <http://pwa.ars.usda.gov/pullman/glgp/>.

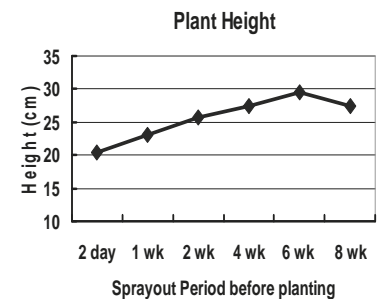
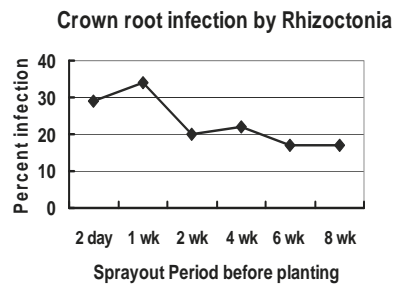
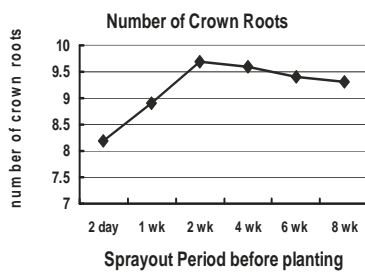
Part 3. Pathology and Entomology

Optimum Timing for Spraying Out Greenbridge with Roundup to Control Rhizoctonia in Barley

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1. USDA-ARS ROOT DISEASE AND BIOLOGICAL CONTROL RESEARCH UNIT, PULLMAN, WA
2. DEPARTMENT OF PLANT PATHOLOGY, WSU

A field experiment was conducted in 2007 in a field at the ARS Palouse Conservation Farm with a high level of both *R. solani* and *R. oryzae*. Volunteer and weeds were allowed to grow over the winter, and plots were sprayed out with Roundup at 8 wks, 6 wks, 4 wks, 2 wks, 1 wk, and 2 days before planting with barley (var. Baroness) near the end of April. Disease and plant measurements were taken 3 weeks after planting. Plots sprayed out 2 days or 1 week before planting showed increased disease and less plant growth. The number of tillers and roots increased with earlier spraying times, 2 and 4 wks preplant. Plant height and leaf length were improved with spraying out up to 6 weeks before planting. The optimum time for spraying out greenbridge was 3 weeks before planting for most measured parameters.



Controlling Soilborne Pathogens in Wheat Production Systems

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COLLABORATORS: NATHALIE WALTER¹, VICTOR DEMACON³

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3. DEPARTMENT OF CROP AND SOIL SCIENCES, WSU

Pacific Northwest (PNW) wheat, barley, legume and canola varieties are susceptible to broad host-range soilborne pathogens that cause *Rhizoctonia* root rot and *Pythium* root rot. Controlling *Rhizoctonia* and *Pythium* will likely require multiple strategies. My laboratory focuses on three research areas: 1) identifying the *Rhizoctonia* and *Pythium* that occur in PNW cereal production systems, 2) identifying and characterizing resistance genes, and 3) utilizing plant genes that enhance biocontrol agents. We have used advanced DNA-based (real-time PCR) assays to show that *R. solani* AG-8 and *R. oryzae* grp III are associated with root rot of wheat, whereas *R. solani* AG-2-1 and AG-10 are pathogenic to legumes and canola. The *Rhizoctonia* occur primarily in low to moderate rainfall zones, in contrast to *Pythium* species, which favor high rainfall or irrigated regions. The Barocycler™ has proven to be an important innovation for the detection of *Rhizoctonia* in soil samples, because high pressure is needed to extract its DNA. Until the generation of the *Rhizoctonia* resistant wheat genotype Scarlet-Rz1 by mutagenesis, non-GMO resistance to root diseases has been elusive. The resistance in Scarlet-Rz1 is readily deployable by wheat breeders, making it unique.



Nathalie Walter operating the Barocycler™

Field trials are in progress to evaluate the performance of this promising new wheat. The mutagenesis approach can be used to generate *Rhizoctonia* resistant canola. Finally, soil bacteria of the genus *Pseudomonas* exert biological control of *Rhizoctonia* and *Pythium*. We have found that PNW wheat cultivars vary in their ability to support high populations of biocontrol bacteria and to accumulate disease-suppressive compounds on their roots. Current research is showing that biocontrol strains of *Pseudomonas* induce defense gene expression in wheat roots, possibly bolstering pathogen defenses.

Control of Stripe Rusts of Wheat and Barley

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3. DEPARTMENT OF CROP AND SOIL SCIENCES, WSU

Rusts of wheat and barley were monitored throughout the Pacific Northwest (PNW) using trap plots and through field surveys during the 2007 growing season. Through collaborators in other states, stripe rusts of wheat and barley were monitored throughout the US. In 2007, stripe rust of wheat occurred in more than 16 states while stripe rust of barley was found in California, Colorado, and Washington, but both stripe rusts generally low due to the weather conditions not highly unfavorable to stripe rust. However, the disease caused yield losses over 50% on susceptible winter and spring wheat cultivars in our experimental plots. Leaf rust was light but stem rust caused severe damage in some barley fields in the PNW. A total of 30 wheat stripe rust races and 5 barley stripe rust races were identified, of which 11 wheat stripe rust races were new. Through cooperation, 16 races were identified from barley stem rust samples collected in Washington. In 2007, we evaluated more than 15,000 wheat and 5,000 barley entries for resistance to stripe rust and other diseases. We mapped one all-stage resistance gene and one high-temperature adult-plant (HTAP) resistance in barley cultivars; and five all-stage resistance genes and four HTAP resistance genes in spring wheat genotypes against stripe rust. To understand molecular mechanisms of stripe rust resistance, we completed studies to profile expressions of genes regulated by the *Yr5* gene for race-specific all-stage resistance and the *Yr39* gene for non-race-specific HTAP resistance using the microarray technology. We identified genes uniquely regulated by the two genes for different types of resistance and also identified expression level polymorphism and single feature polymorphism markers. Forecast models were developed for better prediction of stripe rust epidemics in the PNW. In 2007, we evaluated nine foliar fungicide treatments. Better chemicals, formulations, and application schedules were identified.

Evaluation of Methods for Assessing Resistance to Fusarium Crown Rot in Wheat

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2. IWIS, CIMMYT, ICARDA ANKARA, TURKEY
3. USDA-ARS ROOT DISEASE AND BIOLOGICAL CONTROL 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, of which *F. pseudograminearum* and *F. culmorum* are the most important, reduces wheat yields in the PNW by an average of 35%. Breeding for resistance requires adequate *Fusarium* screening systems. One common barrier in *Fusarium* screening is the large degree of variation in disease infection. The objective of the research was to find the inoculation method with the greatest consistency and least variation. Experiments to assess the pathogenicity of five PNW isolates of *F. pseudograminearum* and the best method of inoculation were conducted during 2007 and 2008. Several genotypes that differed for resistance were planted in cone-tainers in growth chambers and the WSU plant growth facility. Five *Fusarium* isolates were evaluated using five different inoculation methods. Experiments revealed that two *Fusarium* isolates, one collected in Oregon and one collected in Washington, were consistently the most pathogenic across studies. The inoculation method that produced the most consistent results in pathogenicity and differentiation between resistant ('2-49') and susceptible ('Seri') wheat genotypes was the agar conidial suspension (10^6 conidia per μ l) placed in a drinking straw at the stem base of seedlings. We will use this inoculation method to evaluate

recombinant inbred lines from a cross between the Fusarium tolerant Australian cultivar Sunco and the PNW adapted susceptible cultivar Macon. Through this we will identify specific gene regions (QTL) associated with resistance that will allow us to use marker assisted selection as well as controlled growth chamber evaluation of breeding lines and cultivars. We have also established a screening trial in the field at Lind and in a sand bed on the WSU campus in order to evaluate resistance on adult plants, over the whole growth cycle.

Establishing Cereal Leaf Beetle Biocontrols in Washington State

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2. NORTHWEST BIOLOGICAL CONTROL INSECTARY/QUARANTINE (NWBIQ), PULLMAN, WA
3. DEPARTMENT OF ENTOMOLOGY, IAREC-PROSSER, WSU
4. USDA ANIMAL AND PLANT HEALTH INSPECTION SERVICE, SPOKANE, WA

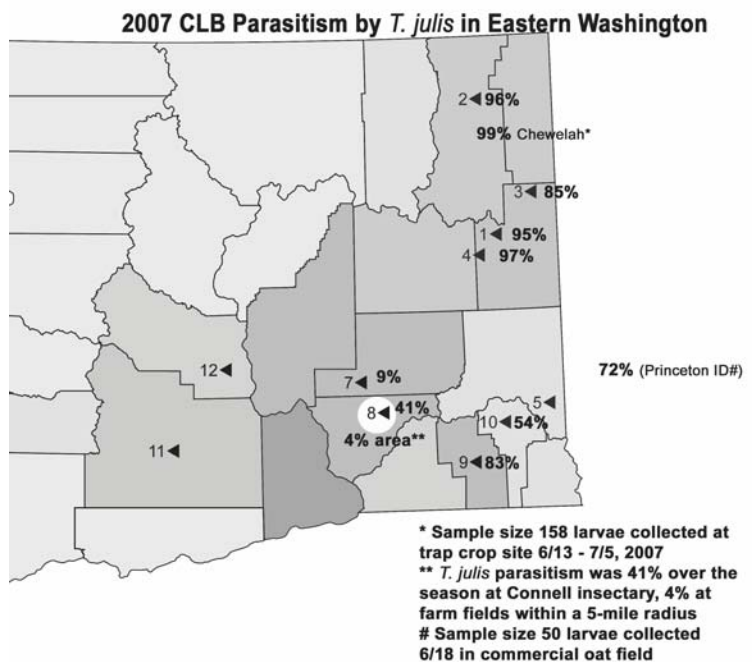
By 2007 the cereal leaf beetle (*Oulema melanopus*) had spread into 18 counties, primarily in eastern Washington. It has a wide host range in the grass family and may cause yield losses up to 75% in spring wheat. Introduced biocontrol species have kept cereal leaf beetle (CLB) at subeconomic levels in midwestern and eastern states.

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

Farmer cooperators, whose fields had high infestations of CLB, have maintained field insectaries where we release the parasitoids. *T. julis* has survived and multiplied extremely successfully. In 2007, parasitism levels of CLB exceeded 90% at most sample sites along the easternmost border of Washington state. Therefore, farmers in the wetter, dryland areas of the state should not need to spray for CLB as the larval parasitoid is establishing in these areas along with the pest.

T. julis populations have not yet reached economic equilibrium with CLB in the irrigated Columbia Basin. Farmers in this region may need to withstand some yield loss while parasitoid levels increase. Currently labeled insecticides kill both the parasitoids and CLB.

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



T. julis parasitoid on a CLB larvas (WSDA photo)

Powdery Mildew of Pea: Pathogen Diversity in Different Environments

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2. USDA-ARS GRAIN LEGUME GENETICS PHYSIOLOGY RESEARCH UNIT, PULLMAN, WA

Powdery mildew of pea caused by *Erysiphe pisi* is an important disease in the Pacific Northwest and elsewhere. Managing powdery mildew relies on planting resistant cultivars and applying fungicides. In pea breeding programs, breeding lines respond differently to powdery mildew infection in greenhouse and field conditions. Some pea breeding lines showed resistance in the greenhouse, but were susceptible in the field. Such inconsistent performances of pea lines could be due to different pathogen populations or species found in various environments.

The objectives of this research were to study the pathogen variation of pea powdery mildew found in greenhouse and field conditions and to find the alternative hosts for pea powdery mildew. Powdery mildew samples were collected from infected pea plants as well as lentil, black medic, and sweet clover from production fields, greenhouses, and natural areas. Identification of the species was based on morphology and selected DNA sequences.

All powdery mildew isolates from pea plants collected from fields are *E. pisi*. However, powdery mildew samples obtained from greenhouse-grown pea plants were either *E. pisi* or *E. trifolii* depending on the time of sampling and greenhouse location. Sometimes greenhouse isolates displayed morphology resembling those of *E. diffusa*.

These data suggest that more than one *Erysiphe* species infect pea under greenhouse conditions. A detached leaf bioassay is being developed to test the precise roles of these two powdery mildew species under greenhouse versus field production conditions. These findings help explain the inconsistent performance of pea breeding lines in various environments. Powdery mildew from black medic and sweet clover had ITS sequences with 99.9-100% similarity to each other and to isolates of pea found in some greenhouses. These weedy legumes could be inoculum sources for powdery mildews in greenhouses and potentially serve as alternative hosts for cultivated legumes.

Part 4. Agronomy, Economics, and Sustainability

Crop-Livestock Integration for Organic Grain Production in the Palouse

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2. CENTER FOR SUSTAINING AGRICULTURE AND NATURAL RESOURCES, WSU

3. USDA-ARS LAND MANAGEMENT AND WATER CONSERVATION RESEARCH UNIT, PULLMAN, WA

Our research analyzes the potential for using grazing livestock to expand organic grain production in the Palouse. Organically certified farm acreage has increased dramatically in the Pacific Northwest, but with less than one-fifth of one percent of Washington wheat acreage certified organic, grain growing in the Palouse has not followed these trends. Our research addresses three obstacles most often cited for slow adoption of organic grain production practices: mechanical strategies for weed and cover crop control, fertility assessment and management, and lack of knowledge of profitability when using livestock and crops together.



Sheep and biomass enclosure.

Our research results provide insights into (1) the degree of tillage necessary to control persistent cover crops and weeds, (2) the impact of tillage on availability of soil nutrients following long-term pastures, (3) yield estimations to be expected from these low input systems, and (4) costs and profit associated with livestock infrastructure and production costs when rotating soil building grazed pastures with annual production of grains, such as wheat.

Pastures were stocked at 2.76 AU/ac for 40 days in May and June (AU=5 sheep). Total herd weight gain was 134 lbs/ac for a gross value of US \$276/ac. Non-grazed alfalfa pasture productivity (hay) was 1.1 ton/ac for a gross value of US \$218/ac. Pasture soil carbon dynamics will be analyzed in 2010. In grain following mechanically terminated alfalfa, N response to degree of disturbance is being analyzed. Organic, unfertilized grain yield was positively correlated to degree of disturbance, ranging from 3.23 to 66.8 bu/ac, with a maximum gross value of \$1,068/ac. Yield was negatively correlated with alfalfa re-growth. Profitability of grain following alfalfa was compared to alfalfa left standing and hayed. Biomass over three cuttings totaled 9.7 ton/ac for a gross value of \$1,947/ac. Use of livestock to facilitate organic grain production may be a profitable form of low external input, highly productive agriculture.

Pacific Northwest Undercutter Project

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2. DEPARTMENT OF CROP AND SOIL SCIENCES, WSU
3. WASHINGTON DEPARTMENT OF ECOLOGY
4. OREGON STATE UNIVERSITY

The goal of this \$905,000 USDA-NRCS Conservation Innovative Grant is to demonstrate and advance the undercutter method for winter wheat–summer fallow farming in the Inland Pacific Northwest. The project, administered by the Washington Association of Wheat Growers, cost shares 50% of the purchase price of an undercutter up to 34 feet in width and equipped to apply fertilizer at the time of primary spring tillage. Farmers accepted into the project are located in wind erosion problem areas in the 12-inch and under rainfall region that encompasses nine counties of east-central Washington and five counties of north-central Oregon. Participating farmers agree to follow a prescribed minimum-tillage program using the undercutter to retain surface residue and increased surface roughness during the fallow period (Fig. 1).



Fig. 1. The Great Plains (left) Duratech Haybuster (right) undercutters shown here slice below the soil surface with minimum surface soil lifting to completely sever capillary pores to halt liquid water movement towards the soil surface as required to retain seed-zone moisture in summer fallow in the low-precipitation region. All undercutters sold to farmers through the PNW Undercutter Project are rigged to deliver either aqua or anhydrous nitrogen during primary spring tillage.

Of the 47 farmers accepted into the project, 30 are from Washington and 17 from Oregon. Location of farmers by county in Washington are: Adams 14, Benton 9, Douglas 2, Franklin 3, Walla Walla 1, and Yakima 1. The Oregon locations by county are: Gilliam 5, Morrow 5, Umatilla 6, and Wasco 1. Specific criteria were established for

undercutters used in the project. The undercutters satisfying the criteria are: the DuraTech 'Haybuster', the Great Plains 'Plains Plow', and the Orthman 'Lazer Plow'. To date, a total of 29 Great Plains Plows, 15 Haybusters, and 2 Orthman Lazer Plows have been purchased.

No-Till and Conventional Tillage Fallow Winter Wheat Production Comparison in the Dryland Cropping Region of Eastern Washington

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2. LINCOLN COUNTY WHEAT PRODUCER

Winter wheat (WW) (*Triticum aestivum* L.) production on tillage based summer fallow systems has been a standard practice for producers in the dryland cropping region of eastern Washington for generations. This practice has been profitable but it comes at a cost that includes soil loss through wind and water erosion. Producers have examined alternative methods including no-till farming systems for maintaining or increasing profitability and reducing soil erosion. A series of on-farm tests were completed over a 5 year period 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 1 month. Conventional methods include a chisel sweep and multiple cultiweeding for fertilization and weed control and seeding with a deep furrow hoe drills. No-till include multiple chemical applications for weed control and seeding and fertilization with a no-till hoe drill with Anderson® paired row openers. Similar to previous research, conventional increased seed zone moisture (0-8") but no differences were detected between treatments in total moisture to a depth of 3 feet. Soil compaction was monitored to a depth of 18 inches in one-inch increments. Less soil compaction was detected in no-till at a depth of 10-16 inches. No difference in grain yield was detected between conventional and no-till early averaging 71-bu/acre. No-till late produced 20% less yield. Economic return above variable costs was similar to yield with no differences between conventional and no-till early and lower when seeding was delayed.

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

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2. DEPARTMENT OF GEOGRAPHY, UNIVERSITY OF GUELPH, GUELPH, ONTARIO
3. CUSTOM PRODUCTS, BIG SPRING, TX

Williston Reservoir in northern British Columbia was created when BC Hydro constructed Bennett Dam on the Peace River in 1968 to generate hydroelectric power. Williston Reservoir is the largest body of freshwater in British Columbia with a surface area of 685 square miles and a shoreline of 680 miles. The First Nation Tsay Keh band was forced to relocate to the north end of the reservoir as a result of the water impoundment. When reservoir levels are at low pool in the spring, 25,000 acres of beach is exposed (Fig. 1). Winds of more than 15 miles per hour create dust storms from exposed beaches that impacts visibility and air quality in Tsay Key village. With funding and coordination by BC Hydro, we initiated a 3-year field research project in 2008 to: (i) evaluate the effectiveness of two tillage practices to mitigate dust from beaches, and (ii) conduct regional dust monitoring at seven sites surrounding Williston Reservoir. The tactic for the



Fig. 1. Wind erosion scientists, Tsay Keh community members, and BC Hydro administrators at a Williston Reservoir beach during a dust storm.

tillage is to bring silt-clay soil from the subsurface to the surface to provide durable roughness. The tillage experiment is located on Ominica Beach and covers 185 acres. Treatments are: (i) tillage with twisted-point chisel with shanks spaced 3 ft apart, (ii) tillage with a lister plow with lister blades spaced 50 inches apart, and (iii) a check. Particulate emissions are measured using an array of 360 Big Spring Number Eight (BSNE) samplers and numerous DustTrak aerosol monitors. Each of the seven regional monitoring sites has a wide array of apparatus to monitor PM_{2.5}, PM₁₀, and total particulates on a 24-hour basis. This research project will have important implications for air quality in British Columbia.

Remote Sensing of Residue Cover in Dryland Farming Area of Central Washington

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Crop residue cover has long been important for erosion control in the dryland agriculture region of the Pacific Northwest. Strong winds often occur during seasonal transition periods, causing substantial amounts of soil erosion and reduction in air quality. Many years of research on cropping systems have been devoted to maintaining a protective cover of crop residue on soils that are typically fallowed to conserve moisture. Monitoring of residue covers is essential to determine the success of practices implemented over time. While there are many years of satellite data available for monitoring we need to learn how to interpret the data for sites that cannot be visited at the time of overpass. Our approach is to understand the spectra of crop residues and background soils to properly interpret the imagery. The objectives are to define and test spectral differences that allow separation of fresh crop residue (mainly wheat and barley), bare soil, old (weathered) residue, as well as permanent grassland, and to develop spectral indexes that will allow us to map areas that have not been visited. Spectral data were collected with a spectroradiometer from 1.5 m above each sample cover. Residue cover data were collected from the same sites. Acceptable regression equations were found using three indexes described in the literature. We also created two new indexes. All of these indexes indicate that differences can be found between soil and residues in the middle infrared wavelengths, 1550 - 1750 nm and 2080 - 2350 nm. We were able to follow soil cover patterns for an entire growing season from May 2000 to May 2001 using satellite images. A poster is available at <http://hdl.handle.net/2376/1373>

Surface Residue and Organic Matter in Dryland Cropping Systems

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Soil organic matter (SOM) maintains soil tilth and structure, provides food for soil life, and increases soil aggregation, soil warming, and air and water flow. Adequate levels of SOM can reduce the negative effects of compaction and crusting, and environmental contaminants. Knowledge of differences in wheat and barley cultivar decomposition rates will assist growers in both high and low precipitation regions where excessive straw production may interfere with planting operations or, conversely, where straw may not be present in sufficient quantity to control erosion. We found that residue quality, and decomposition of straw in soil varied widely among wheat and barley cultivars grown at various locations in Washington. Decomposition is correlated with acid detergent fiber, lignin, total N and C:N ratio. Cultivars with indicators for rapid decomposition are 'Morex' spring barley (SB), 'Macon' spring wheat (SW), and 'Eltan', 'Coda' and 'Stephens' winter wheat (WW). Cultivars with potential for slower decomposition are 'Radiant' SB, 'Nick' and 'Wawawai' SW, and 'Bruehl', 'Finch' and 'Madsen' WW. This research will further quantify fiber, nutrient and tannin characteristics of wheat and barley residue from currently produced varieties and future releases in the Pacific Northwest. This technology may be applied to determine the mineralization and immobilization of nutrients as affected by fiber and nutrient composition of residue. This research will also identify cultivars that are low in lignin content, and suitable for ethanol production. This information may also assist the use of residues for other value-added products such as paper and strawboard manufacturing or in mushroom production. Information on the various cultivars and new releases will aid growers in planning rotations for reduced tillage systems and enhance the adoption of successful

conservation tillage systems that maintain or improve soil organic matter levels and lead to soils of greater productivity that are better able to withstand erosion.

Economics of Irrigated Annual Winter Wheat after Burning and Plowing of Stubble Versus a No-till Wheat-Barley-Canola Rotation

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This study compared production costs and profitability under irrigation of a winter wheat-spring barley-canola rotation using no-till with various stubble management practices versus continuous annual winter wheat with burning and plowing of stubble. The experiment was conducted during 2001-2006 at the WSU Dryland Research Station at Lind, WA. The no-till rotation was sown (i) directly into standing stubble, (ii) after mechanical removal of stubble, or (iii) after burning stubble. The traditional practice of continuous annual winter wheat sown after burning and moldboard plowing was included as the check treatment. Six-year average net returns over total costs were similar over stubble management treatments for the 3-year no-till rotation. Based on long run average prices, annual average net returns were negative ranging from -\$155 to -\$160 per rotational acre. The continuous winter wheat system averaged slightly higher, but still negative, at -\$145/ac. Net returns of the three residue management practices in the 3-year rotation and the continuous winter wheat system were statistically equivalent. Net returns for all systems would be near or above breakeven levels at farmer cooperator yields and the high 2007 crop prices. Winter canola was killed in 5 of 6 years by a combination of cold and rhizoctonia root rot that necessitated replanting to spring canola. Canola was the major economic loser in the 3-year rotation with an average annual loss of -\$247 per acre. Average irrigated winter wheat and canola yields from the experiment were lower than those reported by farmer advisors because of the extreme difficulty of growing no-till irrigated winter canola and the fact that winter wheat, canola, and spring barley all require different timing of irrigation (not possible with hand lines in this experiment). Further research on alternative no-till irrigated cropping systems should probably exclude winter canola, and should be conducted where crop-specific irrigation scheduling is possible.

Crop Yield and Revenue Variability Across Time and Space at the Cook Agronomy Farm, 2001-2006

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Field-size strips of no-till spring wheat, winter wheat, and one of six alternative crops are planted across the hilly terrain of a 92-acre portion of the Cook Agronomy Farm near Pullman, WA. Strips of crop rotation alternatives were arranged perpendicular to the predominant slope in order to capture maximum field variability. After six years of trials (two complete rotation cycles) spring barley yields had the lowest yield variability with a coefficient of variance (CV) of 26%. Interestingly, winter wheat had the highest CV at 191%. Spring wheat had the second lowest CV of 31%.

Net returns to land were calculated based on actual costs and returns by year and by yield measurements taken at 369 georeferenced locations across the landscape. Net returns per acre by strip over the six-year period ranged from a high of \$68 per acre with winter barley as the alternative crop to a low -\$44 per acre for another strip with winter barley as the alternative crop in a different section of the farm. Land quality differences were more important than crop choice in this hilly landscape. However, the three strips with net returns to land greater than \$50 per acre featured alternative crop choices with the lowest CV in the study: winter barley (CV = 31%), spring canola (CV = 38%), and spring barley (CV = 26%). Average returns by alternative crop choice across all strips were also highest for spring barley, at \$40 per acre, and lowest for spring peas, at \$17 per acre. Spring peas had the highest CV of the rotational crops in this study at 73%, as peas have been problematic in this no-till system.

Roger Veseth's Slide Sets to WSU Holland Library Archives

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Before his untimely death in 2003, Roger Veseth, Extension conservation tillage specialist for Washington State University and the University of Idaho, extensively documented erosion and soil conservation in the Pacific Northwest for 19 years with photography. More than 4,000 of his 35mm slides were in storage on the U of I campus. Access to these images is limited and cumbersome. In 2007 we embarked on an effort to preserve Roger's slides and make them accessible on the web. We followed the model of preservation used for the Verle Kaiser collection (<http://vkaiser.wsu.edu/>).

We are currently selecting slides and providing annotation. With the assistance of Holland Library archivist, Trevor Bond, the selected slides will be scanned and stored on the Holland Library website, making them accessible for everyone. The original slides that are scanned will be offered to the archives, also to be accessible by the public. Part of the funding for this project is from an award by the Verle Kaiser Conservation Endowment in the WSU Foundation.

Direct Seeding Technology at Clearwater Direct Seeders Breakfast Meetings: A Venue for Technology Transfer

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A series of breakfast meetings were facilitated in 2007-2008 by Russ Evans, Pacific Northwest Direct Seed Association, and Hans Kok and Dennis Roe, WSU and U of I Extension. The meetings focused on experiences shared by direct seed growers and both WSU and UI scientists. Some international guests from Finland, Australia, and New Zealand shared their experiences with no-till. Meetings were held in Lewiston, and Davenport. Colfax will be added as a venue for 2008. The breakfasts were hosted by local banks, and ag supply companies. Attendance at the meetings ranged from 25 to 93. The length of direct seeding experience by the growers ranges from none to 30+ years.

The meetings in Lewiston were started ten years ago by former county Latah County (Moscow) Extension agent, Dave Barton and some leading growers. This winter Barton received the national Direct Seed Innovator award at the National No-till Conference in Kansas this winter for his work facilitating the Clearwater Direct Seeders meetings.

Spring Topdress Nitrogen Applications on Winter Wheat

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Each year growers face the decision whether or not to topdress winter wheat stands with nitrogen in the spring. Factors such as yield forecast at the time fertilizer was applied the previous year, winter and early spring precipitation levels, over-winter growth and stand condition in the spring, and expected price of wheat at harvest are a few factors that influence the decision to topdress. One main question is when should winter wheat stands receive topdress applications of nitrogen? The purpose of this ongoing Washington Wheat Commission-funded project is to evaluate winter wheat yield and grain protein responses to spring topdress N applications made at different times across the diverse dryland environments in eastern Washington. Hard red winter wheat was planted at three locations (Lind, Davenport, and Pullman) in fall 2006 with base fertilizer rates intended to provide an optimum soil+fertilizer nitrogen supply for hard red winter wheat (3 lb soil+fertilizer N/bushel expected yield). Dry urea was broadcast at a rate of 20 (Lind) or 30 (Davenport and Pullman) lbs nitrogen/acre on March 2, March 22, and April 5. Grain yield, grain protein content, and test weight were determined at harvest. Data are available the first year of this study. The Pullman site was located on a droughty south-facing slope and

there was no statistical response to spring topdress nitrogen. At Davenport, March 2 topdress increased winter wheat yield by 9 bushels/acre while applications made on March 22 or April 5 increased yield by 6 bushels/acre, above the treatment that did not receive spring topdress nitrogen. There was no effect of spring topdress nitrogen on grain protein at Davenport. At Lind, March 2 topdress increased winter wheat yield by 6 bushels/acre and April 5 topdress decreased winter wheat yield by 5 bushels/acre, compared to the treatment that did not receive spring topdress nitrogen. Spring topdress N also resulted in higher grain protein content, but later applications (March 22 and April 5) reduced grain test weight indicating late applications in the moisture limited environment near Lind stressed the crop. Preliminary data from this study suggest the potential to improve winter wheat yield with spring topdress applications of nitrogen. Early applications are necessary to prevent stress and possible yield and test weight declines, particularly in low rainfall environments.

Ammonia Volatilization from Urea in Dryland Kentucky Bluegrass Systems

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Urea has replaced ammonium nitrate as the primary source of nitrogen (N) fertilizer for dryland Kentucky bluegrass seed production in the inland Pacific Northwestern U.S. This research assessed the potential for ammonia (NH_3) volatilization from urea applied in grass seed production systems and the impacts of N loss on seed yield in the field. Laboratory measurements indicate the potential for NH_3 volatilization is greater from stands in which post-harvest residue is baled and removed, leaving a sod surface, than from stands in which residue is burned or from a bare soil surface. Although pH of the residue and ash were both above 8.0, urease enzyme activity in the burned residue was only 6% of the unburned residue and 15% of bare soil. In the field, NH_3 volatilization from broadcast dry urea and surface bands of fluid urea ammonium nitrate solution was greater than ammonium nitrate or an unfertilized control at an unburned site for October 5 and November 15 application dates, and for the October 5 application date at a burned site. The magnitude of NH_3



Kentucky bluegrass research site near Palouse, WA before harvest

volatilization was much higher for urea and fluid urea ammonium nitrate solution after a November 15 application than after an October 5 application, presumably due to higher soil moisture content at the later application date. Higher volatilization was associated with lower apparent nitrogen recovery (percentage of applied N in treated plots above the unfertilized control) in above-ground biomass at harvest and clean seed yield at maturity. Overall, the potential for significant NH_3 volatilization and associated seed yield reductions exists in dryland Kentucky bluegrass stands. Urea or fluid urea ammonium nitrate applications made to burned fields, fields with low moisture content at the surface, or immediately before a significant rain event are necessary to reduce the potential for NH_3 volatilization.

Phosphorus Fertilization of Late-Seeded Winter Wheat in a Chemical Fallow System

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3. USDA-ARS, PENDLETON, OR

Winter wheat (*Triticum aestivum* L.) is produced in the low precipitation (8 to 12 inches) zone of north-central Oregon and east-central Washington using a conventional, summer fallow system. Chemical fallow (CF) is an alternative to the traditional method of farming. Optimism about CF is tempered by an understanding that yield reductions are often a consequence of delayed (late) seeding. Late seeding of winter wheat in CF is necessary because seed-zone moisture during optimum (early) planting dates is frequently less than that required for uniform germination and emergence. Yield reductions from late seeding may be offset, to some extent, by P fertilization.

Effects of fertilization were evaluated in a 3-year field experiment conducted at three locations each year. Phosphorus applied at rates of 10 and 30 lb P₂O₅/acre increased grain yield by an average of 4.1 and 7.3%, respectively. Yield responses among sites ranged from 0 to 14% and were most pronounced on slightly acidic soils where initial soil test (Olsen) P levels were less than or equal to 12 ppm. Yield increases were correlated to improvements in early-season dry matter accumulation, early-season P uptake, and the number of spikes per unit area.

Green Pea Responses to Phosphorus, Sulfur, Boron, and Zinc

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Growers use minimal fertility inputs for legume production in eastern Washington/northeastern Oregon. In 2005, green pea growers in the Walla Walla/Milton-Freewater area expressed interest in assessing the nutrient status of fields and whether more active fertility management could increase yields. Collaborative studies involving Washington State University, Oregon State University and the USDA-ARS were conducted at one location in 2005, one in 2006 (the study failed due to non-viable seed), two locations in 2007, and two in 2008 (results pending). Composite soil samples were collected from the surface 1 foot depth prior to planting and analyzed for macro and micro nutrients by a commercial laboratory. Based on conventional methods of soil analysis all samples tested low in sulfur and boron and several tested low in zinc; levels of phosphorus, potassium, manganese, iron, and copper always tested adequate. Replicated treatments consisting of fluid 11-37-0 or dry 11-52-0 forms of phosphorus (rate = 20 lb P₂O₅/acre), dry phosphorus+sulfur (16-20-0-13/15S; rate = 20 lb P₂O₅ + 13-15 lb S/acre), and fluid phosphorus in combination with zinc (2 lb/acre) or boron (0.25 lb/acre) were evaluated each year. Green pea yield responses to sulfur and boron were common and averaged approximately 500 lb/acre above the unfertilized control. There was a 750 lb/acre yield response to zinc in one year when the soil test was low. There was no response to phosphorus application, but soil test levels did not predict a response at these sites. Overall, soil testing predicted responses to applied nutrients in the majority of situations. Relatively small investments in nutrients when the need is determined based on soil testing can result in large green pea yield increases. These results may have broader implications for dry pulse crop production throughout eastern Washington/northeastern Oregon. Many fields routinely test low in sulfur, zinc and boron, but fields are rarely sampled prior to pulse crop production and even more rarely fertilized with sulfur, boron or zinc.

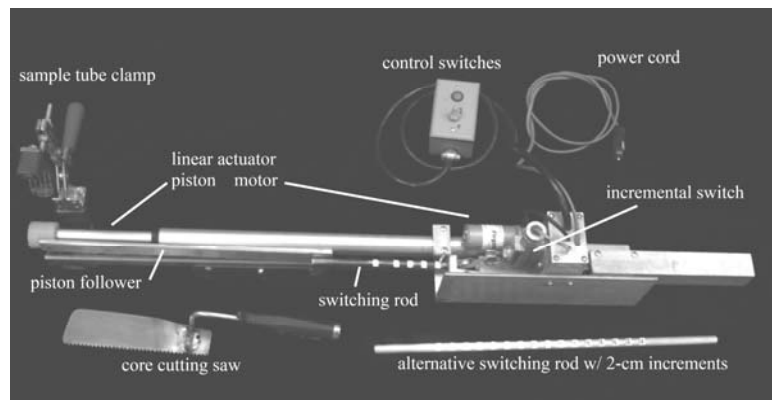
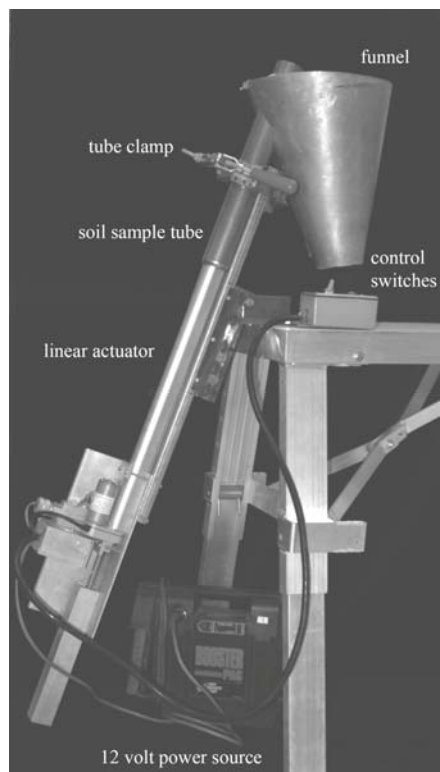
An Improved Method for Soil Sampling at Small Increments

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2. DEPARTMENT OF CROP AND SOIL SCIENCES, WSU

Measurement of soil bulk density and volumetric water content in small depth increments is a tedious and time-consuming task, but very important in many research applications. We designed an electric sampler to improve accuracy and decrease labor requirements. The new method works even in loose, dry soils, and can be used to provide increments at less than 0.5 inch if desired. The sampler uses an electric linear actuator to push an intact soil core out of the sampling tube. The soil core is maintained in a vertical position and protected from fracturing by remaining inside the tube until sectioned with a saw blade. Precise length increments and flat cuts are easily obtained. Compared to existing incremental sampling technology developed 30 years ago for loose, dry soil conditions, the electric sampler had a two-fold reduction in sample variability. The electric sampler requires only 7 minutes to collect a 10-inch core and section it into 13 increments compared to 20 minutes per core with the older sampler.



At left: Electric incremental sampler mounted on a bench for use in the field. The soil core in the sampling tube is pushed out the top of the tube by the linear actuator. Stopping points are controlled by a switch at pre-determined intervals, and the operator cuts the soil core flush with the top of the sample tube.

Above: Details of the electric sampler with the sample tube removed. The switching rod can be exchanged when different depth increments are desired. Also shown is the saw blade used to cut dry, consolidated soil flush with the end of the sample tube without uncontrolled fracture of the core.

Spillman Agronomy Farm Endowment Fund

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

Cook Agronomy Farm Endowment Fund

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

Lind Dryland Research Station Endowment Fund

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

Wilke Research Farm Endowment Fund

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

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

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

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



Blooming winter canola, photo courtesy of Karen Sowers