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Technical Report 02-1

Dedicated to Mr. Dick Hoffman

2002 Field Day Proceedings: Highlights of Research Progress

WSU Dryland Research Station, Lind • June 13, 2002
WSU Wilke Farm, Davenport • June 26, 2002
WSU / USDA-ARS Palouse Conservation Field Station, Pullman • June 27, 2002
WSU Spillman Agronomy Farm, Pullman • July 11, 2002

John Burns and Roger Veseth, Editors

Contributing agencies: Washington State University, U.S. Department of Agriculture and Department of Crop and Soil Sciences
Cooperative Extension programs and employment are available to all without discrimination.

DEDICATION TO DICK HOFFMAN

Dick Hoffman, Farm Manager, WSU Spillman Farm, retired April 30, 2002, after 19 years of service with the WSU Department of Crop and Soil Sciences. Dick has the unique distinction of having served as Farm Manager for each of the Department's research farms (Dryland Research Station-Lind, Spillman Farm-Pullman) during his career.

Dick was born and raised on a cattle ranch in Harrington, WA. While attending Harrington High School, Dick helped his father with a 300-head cow/calf operation that led to his active involvement in the Harrington FFA program, attaining the FFA State Farmer degree in 1965. During his senior year in high school Dick was on the Harrington basketball team that won the State-B basketball championship. The same team placed 2^{nd} in State-B in 1964. His athletic skills followed him to college when he enrolled at Eastern Washington State College (EWSC, now EWU) in 1965, and played on the varsity basketball team as a guard.

Dick and Nancy Richardson were married at Odessa, WA, in 1968. Dick graduated from EWSC in 1969, with a degree in Physical Geography and started working for the Washington State Parks Department as a park ranger at Wanapum State Park near Vantage, WA, until 1971. He was transferred to a park ranger position at Maryhill State Park near Goldendale, WA, in 1973, and remained in that position for three years.

Dick and Nancy have two children, Scot and Stacy, who were born during the time that Dick served as a park ranger. Both children are married and Stacy and her husband have provided Dick the opportunity to be called "Grandpa."

Dick took the opportunity to attend a year of seminary schooling at Regent College, University of British Columbia in 1976. Following seminary training Dick and Nancy moved back to Harrington, WA, where he operated his own 180-head cow/calf operation until 1983. During this time he was also active with the Lincoln County Conservation District and is credited with helping establish the 208 Water Quality Program for the district.

A newly created farm manager position with the Department of Agronomy and Soils at the WSU Dryland Research Station (Lind) became available in 1983, and Dick applied and was selected for the position by Jim Engibous, Chair, Dept. of Agronomy & Soils. The farm manager position at WSU's Spillman farm became available in 1994, and Dick transferred to that position. Even though both Dick and Nancy enjoyed living in the Lind/Ritzville area, greater opportunities were available in Pullman which influenced his decision to transfer to the Spillman farm manager position. Currently, Nancy is an advisor and recruiter for the WSU Intercollegiate College of Nursing.

Dick's expertise in farming will be hard to replace—having managed two research farms requiring such distinctly different cropping systems (low rainfall-Lind & high rainfall-Pullman). He brought a wealth of practical knowledge to the Farm Manager position and can be credited with being an integral contributor to the success of all field research programs conducted at both the Dryland and Spillman Research Stations by crop and soils faculty at WSU.

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

Contributors

Adams Co. Wheat Growers
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Washington Barley Commission
Western Ag Innovations
Western Plant Breeders
Whitman Co. Grain Growers
Wilbur-Ellis
Wilhelm Seed
WSCIA Foundation Seed Service

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Andenberg, Al..............................Fairfield
Andrus, Jeff..................................Lacrosse
Aune, Bud....................................Lacrosee
Ausman, Lynn...............................Anatone
Bauermeister, Dale/Dan................Connell
Bramhall, Cecil.............................Dayton
Bruce, Albert/Doug.......................Farmington
Camp, Steve.................................Dusty
CBARC...Pendleton, OR
Curtis, Al.......................................St. John
Dobbins, Glenn/Bryan.................Four Lakes
Druffel, Leroy..............................Uniontown
Druffel, Mike/Ross.......................Colton
Druffel, Norm/Sons......................Pullman
Druffel, Ross................................Colton
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Ericksen, Tracy............................St. John
Evans, Jim....................................Genesee
Felgenhauer, Karl.........................Fairfield
Fleming, Chad..............................Lacrosse

Fletcher, David..............................Dayton
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Glasco, Paul...................................Moses Lake
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Hennings, Curtis ....Ralston
Hoffman, Dick...............................Pullman
Idaho, Univ. Kambitsch Farms.....Genesee, ID
Jacobsen, Adelbert/Neil...............Waterville
James, Randy................................Dayton
Jirava, Ron.....................................Ritzville
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Johnson, Hal..................................Davenport
Jorgensen, Keith/Owen.................St. Andrews
Juris, Ron ....Bickleton
Koller, Randy/Roger.....................Pomeroy
Kramer, Mark ....Sprague
Kraus, Jerry ....Creston
Lange, Frank..................................Palouse
Lehn, Bernt/Roger ....Farmington
Lyons, Rusty ....Waitsburg
Mader, Steve ....Pullman
Madison, Kent...............................Hermiston, OR
Matsen, Steve................................Bickleton
McCaw, Guy ....Waitsburg
McKay, Dan ....Almira
McKinley, Dan..............................Dayton
Mills, Mac/Rod ....St. John
Moore, Jim/Ann ....Kahlotus
Moore, Steve/Dan.........................Dusty
Nelson, Bruce ....Farmington
Niehenke, Norbert........................Colton
Ostheller, David............................Fairfield
Pittman, Jim/Jeff...........................Rosalia
Pottratz, Dennis ....Fairfield
Rausch, Chris.................................Lexington, OR
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Roseberry, Dave ....Prosser
Rowell, Doug................................Horse Heaven Hills
Ruark, David/Paul ....Pomeroy
Sauer, Bruce ....Lind
Schmitt, Mike ....Prosser
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Schoesler, Mark............................Ritzville
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Swannack, Steve...........................Lamont
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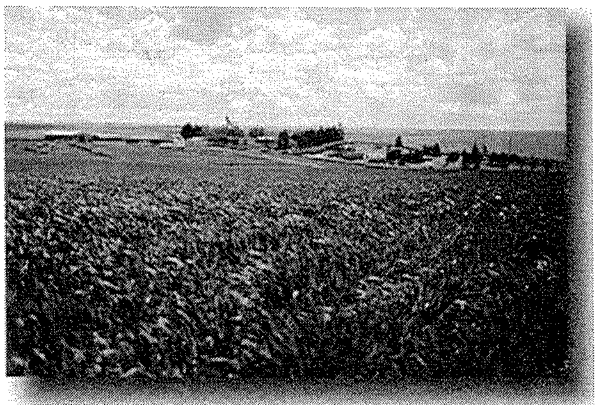
Tanneberg, Larry ....Coulee City
Tee, Larry ....Latah
Thorn, Eric....................................Dayton
Tiegs, Brian ....Fairfield
Torrey, Grant ....Moses Lake
Wellsandt, Don/Doug...................Ritzville
Wesselman, Roger........................Mansfield
White, Dave/Gil............................Lamont
Wilhelm, Edgar ....Rosalia
Zenner, Russ.................................Genesee

HISTORY OF THE DRYLAND RESEARCH STATION

The Washington State University Dryland Research Station was created in 1915 to "promote the betterment of dryland farming" in the 8-to 12-inch rainfall area of eastern Washington. Adams County deeded 320 acres to WSU for this purpose. The Lind station has the lowest rainfall of any state or federal facility devoted to dryland research in the United States.



Buildings and grounds of the WSU Dryland Research Station at Lind.

Research efforts at Lind throughout the years have largely centered on wheat. Wheat breeding, variety adaptation, weed and disease control, soil fertility, erosion control, and residue management are the main research priorities. Wanser and McCall were the first of several varieties of wheat developed at the Lind Dryland Research Station by plant breeding. Twenty acres of land can be irrigated for research trials. The primary purpose of irrigation on the Dryland Research Station is not to aid in the development of wheats for higher rainfall and irrigated agriculture, but to speed up and aid in the development of better varieties for the low-rainfall dryland region.

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

The facilities at Lind include a small elevator which was constructed in 1937 for grain storage. An office and attached greenhouse were built in 1949 after the old office quarters burned down. In 1960, a 40' x 80' metal shop was constructed with WSU general building funds. An addition to the greenhouse was built with Washington Wheat Commission funding in 1964. In 1966, a deep well was drilled, testing over 430 gallons per minute. A pump and irrigation system were installed in 1967. A new seed processing and storage building was completed in 1983 at a cost of $146,000. The Washington Wheat Commission contributed $80,000 toward the building, with the remaining $66,000 coming from the Washington State Department of Agriculture Hay and Grain Fund. A machine storage building was completed in 1985, at a cost of $65,000, funded by the Washington Wheat Commission.

Growers raised funds in 1996 to establish an endowment to support the WSU Dryland Research Station. The endowment is managed by a committee of growers and WSU faculty. Grower representatives from Adams, Franklin, Benton, Douglas, Lincoln, and Grant counties are appointed by their respective county wheat growers associations. Endowment funds support facility improvement, research projects, equipment purchase, and other identified needs. Also in 1996, the state of Washington transferred ownership of 1000 acres of adjoining land to the WSU Dryland Research Station.

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

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 are economically and environmentally sustainable. Focus is on systems that reduce soil erosion by wind and water, improve the efficiency and net return of farming operations, enhance soil quality, and reduce stubble burning.

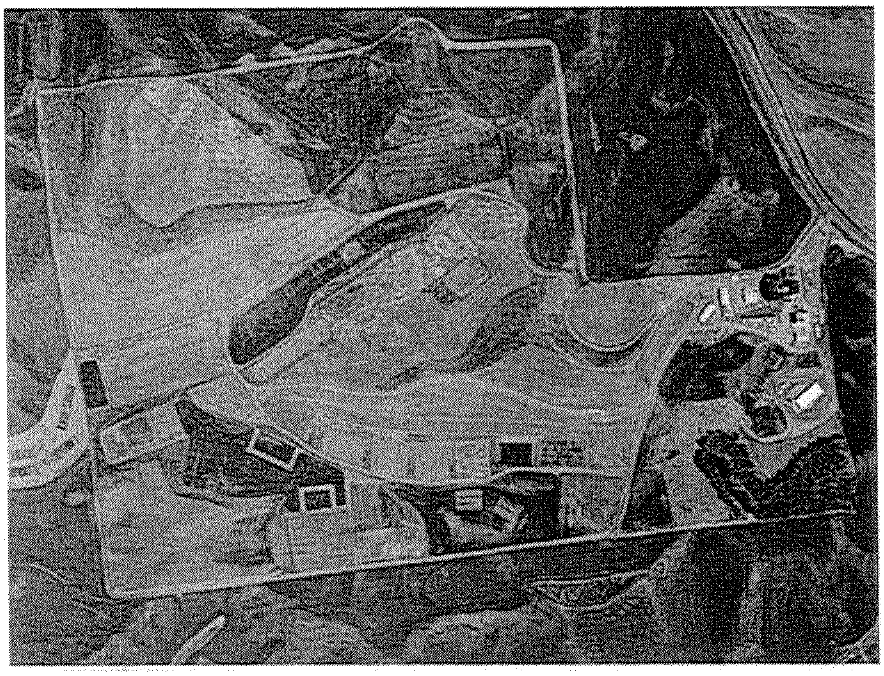
The Wilke Farm is located in the intermediate rainfall zone (12-17 inches of annual precipitation) of eastern Washington in what has historically been a conventional tillage, 3-year rotation of winter wheat, spring cereal (wheat or barley), followed by summer fallow. Wheat is the most profitable crop 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 10 years and being cropped without tillage for the past 5 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. There are three replications of a 4-year rotation (winter wheat, spring cereals, a broadleaf crop, and a warm season grass), and three replications of a 3-year rotation (winter wheat, spring cereals, and a broadleaf crop). Crops grown in the rotation have included barley, winter and spring wheat; canola, peas, safflower, sunflowers, and yellow mustard for broadleaf crops; and proso millet for the warm season grass. Data on soil quality, weed and insect populations, diseases, crop yield, and economics are being collected. 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.

PALOUSE CONSERVATION FIELD STATION

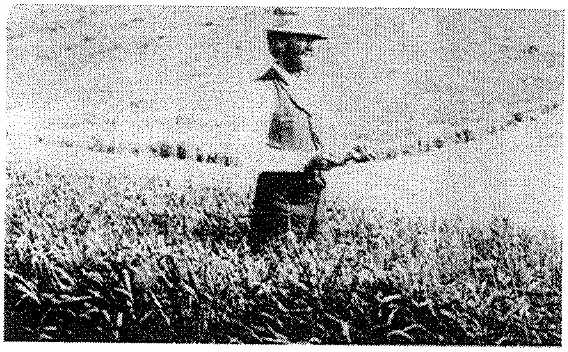
The Palouse Conservation Field Station was established as one of 10 original erosion experiment stations throughout the United States during the period 1929 to 1933. The station consists of a number of buildings including offices, laboratories, machine shop, a greenhouse, and equipment buildings, as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



Aerial view of the Palouse Conservation Farm

HISTORY OF SPILLMAN AGRONOMY FARM

In the fall of 1955, 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. The dedication of the new facility took place at the Cereal Field Day July 10, 1957. In 1961, the Agronomy Farm was named Spillman Farm after the distinguished geneticist and plant breeder at Washington State University in the late 1880s.


William J. Spillman, breeding plots at Pullman, 1900

Through the dedicated efforts of many local people and the initiative of Dr. Orville Vogel, 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 Wheat Commission and Washington State University. The newly acquired 160 acres were fenced and the wetland drained; it became an integral part of the Agronomy Farm, now consisting of 382 acres.

The headquarters building, which is 140 feet long and 40 feet wide, was completed in 1956. A 100- by 40 foot addition was built in 1981. In 1957, a well that produced 340 gallons per minute was developed. In 1968, the Washington Wheat Commission provided funds for a sheaf storage facility that was necessitated by the increased research program on the farm. At the same time 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.

The Spillman Agronomy Farm was developed 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 to the original development of the farm utilizing conservation farming practices breeders are utilizing acreage to develop cropping systems that will include opportunities to include organic, perennial and biotechnological components in cereal and legume breeding programs.

WINTER WHEAT BREEDING AND GENETICS
2001 PROGRESS REPORT

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The purpose of the WSU Winter Wheat Breeding Program is to develop improved varieties of hard and soft winter wheat. New varieties must be more profitable for the grower and meet special adaptation needs for diverse production conditions while reducing environmental pressures.

Field Breeding Hard White and Red Winter Wheat

Development of a hard white and hard red Eltan-type variety is proceeding as planned. The hard red and hard white Eltan-type breeding nurseries have lines that excel in all rainfall zones and several of these lines have been advanced to the variety testing "shadow" nursery. Preliminary quality data from the first of three hard white Eltan-type nurseries located at Pullman and Lind is extremely promising. Data from both locations show 96% had better loaf volume and noodle color scores than Eltan, and of these, 35% also had higher yields than Eltan. Hard red Eltan-types at Lind had 15%, 83%, and 100% of the lines with greater yields than Finley, Eltan and Estica, respectively. At Pullman, 15%, 40%, and 100% had greater yields than Estica, Eltan, and Finley, respectively. We are awaiting final quality results from the 00/01 crop year. All hard wheat lines are intensely screened for disease and all other agronomic characteristics in high and low rainfall zones.

Field Breeding Soft White Winter Wheat

Bruehl (WA7833), a soft white club, was approved for release in 1999, and will be available as certified seed this fall. Although Bruehl has shown wide adaptation in intermediate and high rainfall zones, it was primarily released for the areas of the Pacific Northwest that have severe snow mold problems. It has improved tolerance to local strains of the speckled snow mold pathogen, excellent straw strength and matures earlier than other local snow mold resistant varieties. Bruehl continues to exhibit consistent superior yield potential and excellent club wheat end-use quality in various state's variety testing trials. In our Franklin County emergence trial, Bruehl was statistically equal to Edwin and Moro for both initial emergence and final stand establishment. Its coleoptile length is similar to Lewjain's.

We now have 50 *Cephalosporium gramineum* (Cg) resistant breeding lines in replicated yield trials in multiple field locations. These are the only lines in the world with true Cg resistance. The resistance was transferred from wild species into popular soft white common varieties. Several of the resistant breeding lines performed extremely well under both inoculated and natural field conditions and had very good quality. It is unknown exactly how much yield reduction is occurring each year due to Cg stripe, but results from our yield trials show a yield increase of 6 to 18% over released varieties even under low disease pressure. Again this year, the entire Cg nursery (50 lines) is being evaluated in replicated yield trials at 4 locations across the state. The top lines from these trials are entered into our most advanced nursery. The most promising line from the "first generation" of true Cg resistant wheat is in the variety testing "shadow" nursery. We are continuing to cross the most popular soft and hard winter wheat varieties to the best Cg resistant breeding lines and have many lines in early generation head rows in a Cg inoculated nursery.

Breeding lines with foot rot resistance in an Eltan background have been narrowed to the top 30 based on field and laboratory evaluations. This nursery is now in replicated yield trials at several locations across the state. The top lines from these trials have been entered into the variety testing "shadow" nursery.

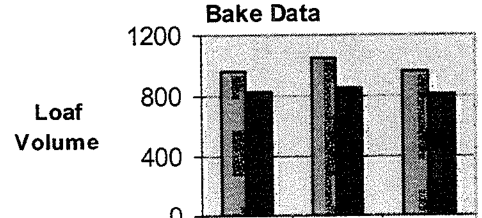
00/01 Advanced White Yield Breeding Nursery

Variety	Yield (bu/a)								
	Colton	Connell	Connell late	Lind Fus.	Mansfield	Pullman	Ritzville	Waterville	statewide mean
Madsen	107.4	44.3	37.7	22.8	58.1	114.9	35.7	87.0	63.5
Eltan	127.6	47.8	41.6	21.3	64.4	116.4	38.9	149.9	76.0
Lewjain	115.4	49.8	38.9	24.1	65.9	123.2	43.0	130.0	73.8
Rod	109.6	44.2	36.2	30.2	64.3	128.5	46.4	112.4	71.5
Stephens	112.7	47.2	37.6	25.0	46.7	109.6	41.0	64.9	60.6
Bruehl	121.9	48.7	30.5	21.7	65.9	127.1	50.4	130.6	74.6
VO95010	128.6	47.6	40.2	25.7	70.5	119.0	45.0	129.1	75.7
VO95014	102.8	45.6	38.6	29.2	65.3	119.4	44.0	128.1	71.6
VO95065	125.1	51.4	41.7	27.2	68.0	124.4	52.9	120.3	76.4
VO95280	113.4	48.2	39.1	26.9	63.8	127.9	37.7	103.7	70.1
VO96406	122.3	47.1	40.1	29.1	68.2	141.4	47.6	122.9	77.3
VO96407	137.8	47.4	38.1	28.5	69.7	140.0	36.1	120.2	77.2
V096408	133.6	46.9	39.8	28.2	61.6	125.5	34.9	109.5	72.5
VO96409	112.8	47.3	40.8	30.5	69.8	139.8	33.4	110.8	73.1
VO96410	130.5	44.8	36.0	30.8	64.9	129.1	36.6	120.3	74.1
VO96411	140.3	44.6	38.6	35.5	64.0	132.2	45.0	116.9	77.1
VO96511	128.3	49.4	37.6	31.8	63.9	132.3	47.3	130.1	77.6
J950297-005	124.1	45.4	29.1	25.4	59.7	112.3	36.9	98.2	66.4
J950288-001	117.3	47.4	35.3	33.8	61.2	118.6	53.5	96.4	70.5
J950077-003	130.1	50.6	40.5	33.0	67.9	111.2	45.6	108.9	73.5
J950077-004	125.8	39.0	35.3	27.6	63.5	103.9	46.3	106.0	68.4
J950087-001	127.3	48.6	35.8	31.4	63.0	118.8	45.9	96.8	70.9
J950315-001	123.0	43.6	34.4	34.6	71.5	121.6	48.2	130.2	75.9
J950276-001	122.1	52.2	37.5	34.2	67.9	136.8	59.1	119.1	78.6
J950081-001	136.7	43.7	33.2	28.0	61.5	135.6	50.0	90.1	72.3
J950297-004	118.3	36.9	33.2	29.5	60.5	115.3	44.9	124.2	70.3
J950297-003	136.7	48.5	39.8	33.1	58.5	116.9	49.1	69.8	69.0
J950086-002	113.0	42.8	33.9	26.0	53.1	104.1	40.0	116.6	66.2
J950274-001	138.3	44.7	42.6	34.1	59.0	129.6	40.3	103.2	74.0
6J950411-03	132.8	39.3	40.5	32.0	68.1	125.6	40.5	124.2	75.4
6J950412-01	133.5	46.7	43.6	32.5	56.8	108.5	47.7	103.4	71.6
6J950370-02	124.2	41.9	36.3	31.0	64.3	136.9	50.2	140.6	78.2
6J950411-02	125.8	37.8	31.3	24.5	54.1	109.4	51.2	96.7	66.3
6J950346-01	122.6	45.1	34.4	28.8	48.5	108.2	43.0	88.4	64.9
6J950411-10	130.0	41.2	33.6	30.2	60.4	117.5	44.0	95.5	69.1
Nursery mean	124.3	45.6	37.2	29.1	62.7	122.3	46.5	111.3	72.1
CV%	16.6	13.0	13.5	18.4	10.7	6.8	19.0	13.4	
LSD@.05	28.9	8.3	7.1	7.5	9.4	11.6	46.5	20.9	

Hard White Eltan 1

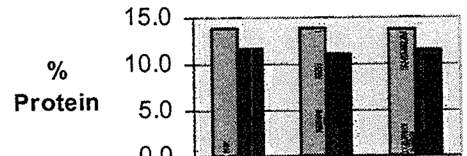
Variety	Yield (bu/a)	
	Pullman	Lind
3J980973	126.8	29.3
3J980630	123.0	29.7
3J980937	**121.3**	**36.5**
3J980834	117.9	29.5
3J980740	116.6	27.2
Eltan	**115.8**	**31.6**
3J980632	**115.0**	**31.9**
3J980855	114.7	32.5
WA7835	113.4	20.1
3J980830	113.1	33.1
3J980640	111.4	31.7
3J980926	111.0	32.4
3J980927	110.8	27.5
3J980801	109.5	24.1
3J980628	109.5	30.7
3J980939	107.5	35.6
3J980670	106.4	30.4
3J980671	103.6	27.3
3J980635	103.5	26.1
3J980807	102.2	22.9
3J981123	100.2	32.3
3J980639	100.1	25.8
3J980638	97.4	26.1
3J980637	95.6	31.2
3J980636	94.8	30.3
Nursery mean	109.6	29.4
CV%	9.4	28.6
LSD@.05	14.4	11.9

Bake Data



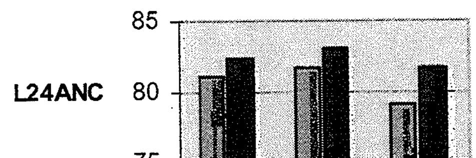
	J98937	J98632	Eltan
Lind	960	1055	955
Pullman	830	860	810

Whole grain protein



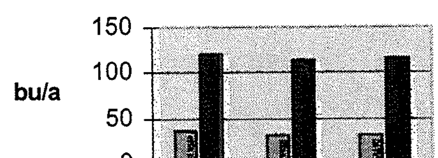
	J9893	J9863	Eltan
Lind	14.0	13.9	13.8
Pullman	11.8	11.1	11.5

Noodle Color Score



	J98937	J98632	Eltan
Lind	81.2	81.7	79.2
Pullman	82.4	83.2	81.7

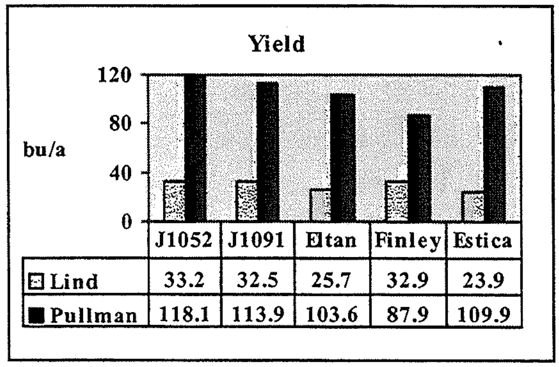
Yield

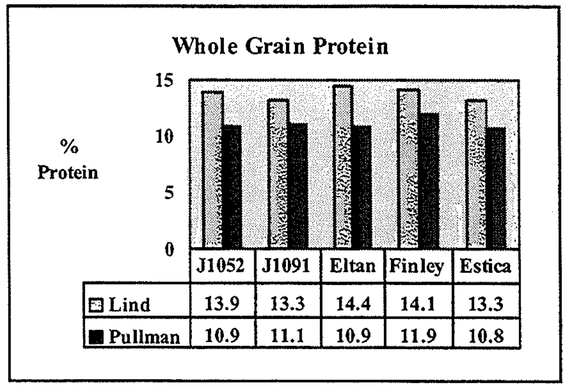


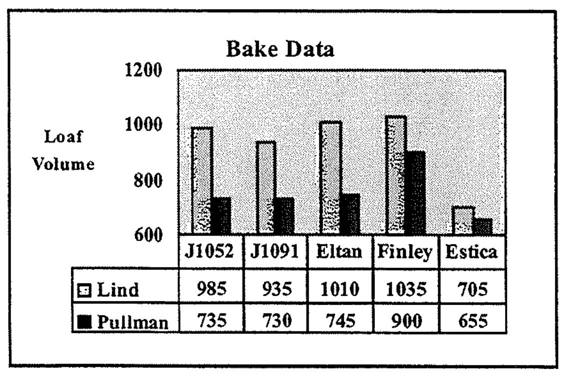
	J98937	J98632	Eltan
Lind	36.5	31.9	31.6
Pullman	121.3	115.0	115.8

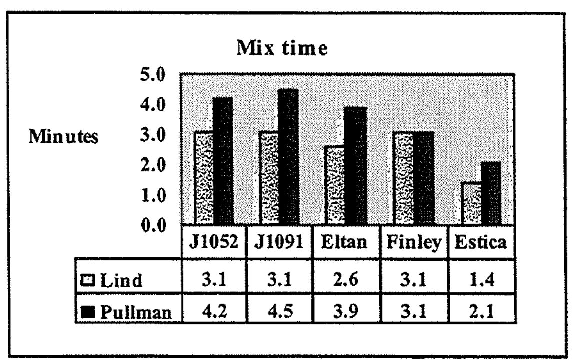
Hard Red Eltan

Variety	Yield (bu/a)	
	Pullman	Lind
J1052	118.0	33.2
J1091	113.9	32.5
J1113	113.8	35.7
Estica	109.9	23.9
J1111	108.1	31.6
J1051	107.4	28.5
J1110	106.8	27.2
J1120	106.8	26.4
J0989	106.0	30.3
Eltan	103.6	25.7
J0997	103.4	29.3
J1107	102.5	34.3
J1019	101.5	23.8
J1109	98.4	29.4
J1114	95.9	26.0
J1121	95.5	30.3
J0992	94.3	28.3
J1103	89.8	25.7
J1122	88.1	25.1
Finley	87.9	32.9
Nursery mean	102.6	29.0
CV%	9.1	32.7
LSD@.05	15.4	13.4









Cephalosporium Inoculated Nursery

1999-2001 (3-year average)			
Variety	Yield bu/a	Test wt. lbs/bu	Disease Index*
J98C0002	96.4	59.3	11.0
J98C0001	94.4	59.5	6.3
Madsen	88.6	56.2	14.5
J98C0005	81.3	59.7	6.9
WA7437	79.4	57.9	2.1
J98C0006	78.6	60.5	4.8
J98C0003	78.1	57.9	10.6
J98C0004	75.9	58.5	6.3
J98C0007	75.0	59.6	13.2
Stephens	70.4	54.8	33.3
J98C0008	67.2	57.3	4.7
J98C0009	63.8	59.6	4.2
Spitzer	35.2	31.8	2.8

2000-2001 (2-year average)			
Variety	Yield bu/a	Test wt. lbs/bu	Disease Index*
Madsen	112.9	60.8	14.5
J99C0009	107.3	61.0	8.6
J99C0008	104.9	61.7	11.9
J99C0002	100.6	58.8	18.9
J99C0005	96.2	60.6	15.5
J99C0003	95.9	58.4	24.8
J99C0007	90.8	59.1	9.3
J99C0011	84.3	60.4	6.4
Stephens	82.9	57.7	33.3
J99C0010	82.9	59.9	5.1
WA7437	81.7	59.3	2.1
J99C0001	75.3	58.9	20.8
J99C0012	74.7	61.3	5.5
J99C0006	69.2	60.4	10.0
J99C0015	68.6	60.3	8.8
J99C0013	60.7	59.7	7.3
J99C0004	43.5	58.8	5.8
Spitzer	33.6	47.7	2.8
J99C0014	31.0	59.3	4.3

* smaller number is better

CLUB WHEAT CULTIVAR DEVELOPMENT AND SOFT WHEAT GERMPLASM ENHANCEMENT: USDA-ARS WHEAT BREEDING AND GENETICS

Kim Garland Campbell, Nathan Blake, Lynn Little, Isobel Alicia Del Blanco, Latha Reddy, Ben Sakkarapope, Eric Weir, Robert E. Allan, Camille Steber, Dan Skinner, Craig Morris, Brady Carter

A mild winter in Eastern Washington, Northern Idaho, and Northeastern Oregon in 2001 was followed by a cool spring and moderate summer, but lack of rainfall resulted in drought conditions throughout the region. Disease pressure was light. State average yields of winter wheat were 61 bu/a in WA, 40 bu/a in OR and 73 bu/a in ID. In Washington, soft white wheat was the predominant class grown with 1,476,700 acres planted; club wheat acreage was 12% of the total crop or 228,600 acres. Club wheat comprised 6% of total wheat production (555,000 acres) in Oregon and 2.3% (29,000 acres) in Idaho.

As part of the USDA-ARS Wheat Genetics, Quality, Physiology, and Disease Resistance unit, the objectives of the ARS breeding and genetics program are:

- To develop club wheat cultivars and wheat germplasm with
  - better emergence
  - improved winter hardiness
  - improved end-use quality
  - resistance to rusts and soilborne disease
  - resistance to preharvest sprouting,
- To coordinate the Western Regional Nurseries.

ARS Yield trial locations included Harrington, Lind, Pullman, St. Andrews, and Walla Walla in Washington; Lexington, Echo, Moro and Pendleton in Oregon; and Genesee, Idaho. Separate nurseries were established to evaluate resistance to foot rot (*Tapesia yallunde*), stripe rust (*Puccinia striiformis*), and cephalosporium stripe (*Hymenula cerealis*) and emergence.

Ten ARS breeding lines were evaluated by WSU Variety Testing in Shadow nurseries at Anatone, Bickleton, Colton, Connell, Creston, Dayton, Dusty, Fairfield, Farmington, Horse Heaven, Lamont, Reardan, Ritzville, St. Andrews, St. John, and Walla Walla WA. Plots were also established in cooperation with the WSU winter wheat

Field plots evaluated in 2001

Nursery	**Entries**	**Locations**
WSU Variety Trial (conducted by WSU variety testing)	3	17
Shadow (conducted by WSU variety testing)	10	16
ARS Elite replicated	36	10
ARS Advanced replicated	36	7
ARS Tall replicated	25	7
ARS Preliminary replicated	180	6
ARS Purification replicated	36	2
ARS Purification Head Rows	4,200	1
Regional breeding nurseries (Western soft, Western Hard, Eastern Soft)	96	2
ARS F_4 Head Rows	6,511	4
ARS F_3 Head Rows	17,250	1
ARS F_2 populations	492	1
Genetic studies	1,007	1-3
Crosses	500	GH
Total ARS plots (excluding Variety Testing)		**1,238,617**

breeding program, the Columbia Basin Agricultural Research Center in Pendleton, OR and the Plant, Soil and Entomological Sciences Dept. of the Univ. of Idaho.

Twenty-one entries contributed by breeders from throughout the Pacific Northwest were evaluated in the Western Regional Hard Winter Wheat Nursery, 31 entries in the Western Regional Soft Winter Wheat Nursery, 27 in the Western Regional Hard Spring Wheat Nursery and 14 in the Western Regional Soft Spring Wheat Nursery. Seven ARS breeding lines were sent to the 2002 regional nurseries. They are: ARS97134, ARS97173, ARS99105, ARS9913, ARS00103, ARS00150, and ARS00187. ARS99105 and ARS99137 were developed from populations that came to us from the OSU club wheat breeding program. All entries have both foot rot resistance derived from VPM (the source of resistance in Madsen), and resistance to stripe rust from various sources.

Finch soft white winter wheat was released in February 2001 because of its combination of yield potential, and disease resistance with the excellent end-use quality characteristics desired for soft white wheat in the Pacific North West. Finch is a strawbreaker foot rot and stripe rust resistant complement to Madsen with a 5% yield advantage, slightly better emergence, more consistent yields in low and intermediate rainfall zones, better test weight, and significantly better end use quality. The target production area of Finch is the low to intermediate rainfall zones of Washington State, Oregon and North Idaho south of WA State Route 2.

Soft White Common 2001 WSU Commercial Variety Trial

Name	Dry	Dry-Int	Int	High	IRR	Mean
A96105	46	82	99	114	141	87
ELTAN	46	87	103	117	124	89
FINCH	49	86	107	121	143	92
LAMBERT	46	83	107	118	145	90
MADSEN	41	81	100	121	150	87
OR939526	45	86	108	129	152	93
ROD	46	87	108	127	146	93
STEPHENS	41	80	108	119	146	88
WEATHERFORD	42	81	101	118	148	87
WESTBRED 470	39	78	104	114	134	85

Yield Data in Bushels per acre from Burns et al., 2001, http://variety.wsu.edu/.
Means were calculated across environments within each rainfall zone.

Soft White Club 2001 WSU Commercial Variety Trial

Name	Dry	Dry-Int	Int	High	IRR	Mean
BRUEHL	44	85	111	124	150	92
CHUKAR	43	88	109	120	136	91
CODA	44	85	103	120	128	89
EDWIN	48	77	95	105	120	82
HILLER	44	89	113	125	135	93
RELY	43	88	106	118	127	89
ELTAN	46	87	103	117	124	89
MADSEN	41	81	100	121	150	87

Yield Data in Bushels per acre from Burns et al., 2001, http://variety.wsu.edu/.
Means were calculated across environments within each rainfall zone.

Chukar winter club wheat (*Triticum aestivum* L.) was released in September 2001 because of its combination of yield potential, and disease resistance with the quality characteristics desired for club wheat. Yields of Chukar have been equal to or up to 5% better than those of 'Coda' club wheat and 'Madsen' soft white winter wheat over five years of multi-location yield trials in the Pacific Northwest. Chukar is a replacement to the club wheat 'Hiller' in intermediate to high rainfall environments when foot rot is a problem. Chukar is best suited to the intermediate to high rainfall zones of Washington State and North Idaho.

Test Weight, Commercial Winter Wheat Variety Trial, 2001

	Mean
Soft White Common	
ELTAN	60.6
FINCH	61.2
LAMBERT	60.4
MADSEN	60.4
OR939526	59.5
ROD	59.1
STEPHENS	59.9
WEATHERFORD	60.4
WESTBRED 470	62.9
Soft White Club	
BRUEHL	59.0
CHUKAR	59.1
CODA	61.3
EDWIN	61.5
HILLER	58.5
RELY	60.4

Test Weight Data in Lbs/Bu from Burns et al., 2001, http://variety.wsu.edu/

Quality and test weight are a priority in the ARS breeding program. The test weight of Chukar is good while the test weight of Finch and Coda, available as certified seed for the first time in 2001, are excellent.

The milling performance of Finch was similar to Eltan, Madsen and Stephens (milling score of 85.6, 85.6, 85.2, and 85.0 for Finch, Eltan, Madsen and Stephens respectively). Finch has statistically superior test weight, flour yield, and break flour yield, but the flour ash of Finch is higher than that of Eltan, Madsen, and Stephens. The mixograph water absorption is lower than Eltan and Madsen, equal to Stephens (53, 54, 54, and 53 % for Finch, Eltan, Madsen and Stephens respectively). The cookie spread is wider than Madsen and Stephens and similar to Eltan (9.4, 9.4, 9.1, and 9.2 cm for Finch, Eltan, Madsen and Stephens respectively). The flour swelling volume of Finch is lower than that of Eltan, and Stephens and equal to Madsen. The flour rapid visco-analysis (RVA) is significantly lower than that of Eltan, Madsen, and Stephens. The improved baking quality over Madsen justifies its release on quality considerations alone.

The end use quality of Chukar is excellent as compared with other club wheat varieties. Grain protein of Chukar was 7.2%, 0.6% lower than Coda. The milling score of Chukar was 88.4, similar to Coda and better than Rely. Flour yield of Chukar was 71%, similar to Coda and Rely but break flour yield of Chukar was 53%, 1% higher than those cultivars. Cookie diameter was 9.6 cm, 0.2 cm greater than Coda and Rely. Sponge cake volume of Chukar was 1304 cc, similar to Rely and 50 cc more than Coda. Chukar is expected to increase the overall quality of the wheat crop in Washington.

We have evaluated several commercial wheat cultivars for cold hardiness using LT50 tests in the walk-in growth chambers at the WSU Wheat Plant Growth Facility. These tests determine the genetic resistance to freezing under controlled conditions. Other causes of winter injury include rapid temperature changes prior to full cold-acclimation or temperature changes in mid-winter which result in deacclimation, desiccation due to lack of snow cover, freeze-thaw cycles which heave plants out of the ground, suffocation due to ice sheeting in fields, and frost injury to the emerging inflorescence.

Winter injury to roots creates an entry point for disease. Cold temperature injury is also a production risk factor for spring cereals, especially in conservation tillage cropping systems where stubble on the soil surface reduces soil temperatures and slows germination. Because of these interactions, the LT50 values should be interpreted on a relative basis. In order to determine winter survival, include other information like the growth stage of the crop at the time of severe temperature stress, the disease resistance of the cultivar, and the moisture available.

Cultivar	LT50	Cultivar	LT50
A96105	-12.15	ID52814A	-12.24
Albion	-12.56	J950127-	-12.35
BASIN	-11.32	J950131-	-14.46
Bavaria	-13.81	Lambert	-10.73
BEAMER	-10.34	Lewjain	-11.65
Brundage	-11.67	Macvicar	-11.29
BU6W93-4	-11.87	Madsen	-11.45
Cashup	-12.45	MJ-4	-11.63
Daws	-14.51	MJ-93-1	-11.43
Eltan	-15.05	N9502606	-13.49
Eltan-Madsen	-13.31	N9504703	-11.16
Estica	-12.38	OR939526	-10.89
Finch	-10.34	PB25W33	-13.62
GM000001	-13.13	Pillar	-11.93
GM000002	-14.35	Residence	-11.15
GT4-115	-12.62	Rod	-11.16
Hill81	-12.26	Semper	-9.77
HUBBARD	-10.44	Stephens	-10.91
ID10085-	-11.03	Weatherforn	-10.74
ID17113A	-11.01	WPB470	-11.22

	Cultivar	LT50		Cultivar	LT50
HRW	Boundary	-14.66	WHCL	Bruehl	-12.2795
HRW	Buchanan	-13.80	WHCL	Chukar	-12.9886
HRW	Centurk78	-15.02	WHCL	Coda	-11.2513
HRW	Finley	-13.79	WHCL	Edwin	-13.9991
HRW	Hatton	-14.61	WHCL	Hiller	-11.3028
HRW	IDO00517	-13.46	WHCL	Hyak	-14.086
HRW	IDO00550	-12.37	WHCL	Jacmar	-15.5884
HRW	Karl	-10.94	WHCL	Moro	-10.9774
HRW	N9502203	-14.31	WHCL	Paha	-11.4377
HRW	N9502601	-12.01	WHCL	Rely	-12.3482
HRW	N9505403	-14.88	WHCL	Rohde	-10.3078
HRW	N9988121	-11.59	WHCL	Temple	-12.2875
HRW	QHYB542	-14.78	WHCL	Tres	-11.7697
HRW	Wanser	-14.58	WHCL	WA7871	-13.8196
HRW	Weston	-12.04			

L.S.D = APPROX. 2.8

STRAWBREAKER FOOT ROT, CEPHALOSPORIUM STRIPE, AND SNOW MOLD DISEASES OF WINTER WHEAT

Tim Murray, Larry Pritchett, Leila Vasquez, Sharon Tsai, and Hongjie Li
Department of Plant Pathology, WSU

Strawbreaker foot rot (also known as Eyespot) and Cephalosporium stripe are two of the most important diseases of winter wheat in the Inland Pacific Northwest. These diseases are most common in the high rainfall areas (more than 18" annual precipitation), but can cause significant losses in the lower rainfall areas, too. Early-seeded winter wheat has the greatest risk of being affected by these diseases, especially when planted following summer fallow. Grain yield in fields where either of these diseases is severe may be half or less than that of fields where these diseases are not serious. The snow mold diseases are limited to the northernmost wheat-producing areas of Lincoln, Douglas, and Grant counties and southern Okanogan County where snow cover frequently persists for 100 days or more. Left uncontrolled, all plants in a field can be killed when snow mold is severe.

Disease-resistant varieties are the most desirable control measure for all three of these diseases. Varieties with resistance to strawbreaker foot rot and the snow molds are available and used widely. Varieties with resistance to Cephalosporium are not currently available however.

Cephalosporium stripe is controlled by delaying seeding in the fall (in fields seeded early relative to the production area), increasing the length of crop rotation so that winter wheat is grown one year in three, and by increasing tillage to promote decomposition of crop residue infested with the pathogen. None of these practices completely control the disease, and all may have undesirable consequences such as increased soil erosion potential or decreased yield potential.

Table 1. Cephalosporium stripe disease index, yield, and test weight of winter wheat varieties and breeding lines, Spillman Farm, 2001.

Variety	Disease Index	Yield, bu/ac	Test weight, lbs/bu
WA7437	4.6	84.9	60.9
AT3425	10.1	40.1	57.1
Eltan	***12.7***	***96.0***	***61.6***
VO95014	14.2	94.2	60.9
Daws	14.5	95.2	61.9
WA7853	14.6	100.1	61.9
WA7871	17.1	87.1	59.7
Madsen	19.1	97.1	61.3
Rod	21.2	86.8	60.3
Albion	21.9	78.5	60.2
Bruehl	23.6	97.4	60.5
Edwin	24.3	79.2	61.7
Coda	26.6	86.1	62.3
WA7855	29.6	100.1	60.9
Cashup	32.0	90.5	61.2
Lambert	34.6	95.9	59.1
Hill 81	37.5	102.9	61.4
Hiller	39.6	76.7	58.1
Stephens	43.5	62.8	56.6
LSD 5%	**18.3**	**NA**	**NA**

Disease index ranges from 0 to 100, where 0= all healthy plants with no visible symptoms and 5= all diseased plants with stripes in the flag leaf or head. AT3425 is a wheat-wheatgrass hybrid that is perennial. LSD= least significant difference: Two figures in the same column must differ by this amount to be considered statistically different.

Resistance to Strawbreaker and Cephalosporium. Field plots to screen winter wheat cultivars and breeding lines for resistance to Cephalosporium stripe have been conducted at the Spillman Agronomy Farm from 1998 through 2002, as part of our continuing effort to improve the resistance of commercial varieties to this disease. In 2001, overall disease severity was only moderate. Disease index ranged from a low of 4.6 for WA7437 to 43.5 for Stephens (Table 1). Yield and test weight ranged from 102.9 to 40.1 bu/A and 61.9 to 57.1 lb/bu, respectively. Eltan had the lowest disease index for commercial varieties and WA7437 had the lowest disease index among all lines tested. Several breeding lines including VO95014, WA7853, and WA7871 had low disease index and yield potential comparable to Eltan.

Studies are in progress to determine the number and location of genes in AT3425 conferring resistance to Cephalosporium stripe to aid in transferring resistance to adapted winter wheat lines. Three breeding lines were identified that contain short translocations of wheat grass chromosome that are thought to carry the gene(s) for resistance to Cephalosporium stripe. Genetic analysis of these lines is necessary to demonstrate that the translocation is carrying the resistance genes and to determine its mode of inheritance in progeny plants. Ultimately, we want to develop molecular markers for these resistance genes in order to accelerate the development of Cephalosporium stripe resistant varieties.

In our program, potential new varieties are first evaluated for resistance to strawbreaker foot rot in a growth chamber seedling assay. Those lines that appear resistant are then tested under field conditions by inoculating them with the pathogen and measuring disease development and yield. Growth chamber tests allow us to eliminate most of the susceptible lines before field-testing, which improves our efficiency and reduces the cost of testing. Over 100 progeny lines from a cross between Eltan and Madsen were evaluated for resistance to strawbreaker in the greenhouse and the most resistant 30 lines were sown in September 2000 and again in 2001. Several of these lines exhibited very good resistance and yield potential and will be evaluated for disease severity and yield during summer 2002. The best of these lines will be considered for release as a commercial variety after further field testing.

In addition to improving strawbreaker resistance in varieties, we are also evaluating pathogenic variation in the strawbreaker fungus. Two different but closely related fungi cause strawbreaker in Washington State: *Tapesia yallundae* and *T. acuformis*. In previous studies, *T. acuformis* was relatively uncommon in the PNW. However, over the past 3 years we collected over 800 isolates of these fungi and found more than 40% were *T. acuformis*. This is significant because *T. acuformis* is reported to be more virulent on varieties containing the *Pch*1 resistance gene, which is the only strawbreaker resistance gene currently in commercial varieties in the PNW.

A field study was conducted to determine whether interactions occur between strawbreaker resistance gene *Pch*1 (found in Madsen) and *T. yallundae* and *T. acuformis*. Disease progress curves were developed for Madsen and Hill 81 inoculated with each fungus (Fig. 1). Disease on Madsen was greater when inoculated with *T. acuformis* than *T. yallundae*, but there was no difference in yield between these fungi (79.0 and 78.5 bu/ac, respectively). On Hill 81, disease was greater when it was inoculated with *T. yallundae* than *T. acuformis* and yield was significantly less for *T. yallundae* than *T. acuformis* (61.2 and 89.5, respectively). Based on these results, it appears that *T. acuformis* may be more important on varieties containing resistance gene Pch1 and therefore this work is being continued.

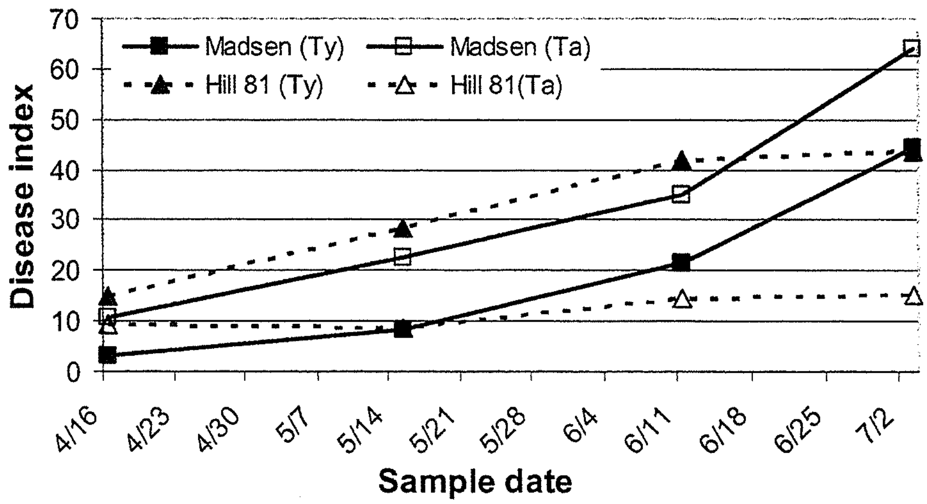


Figure 1. Disease progress curves for Madsen and Hill 81 inoculated with *Tapesia yallundae* and *T. acuformis*.

<u>Resistance to snow mold</u>. Bruehl is a relatively new snow mold resistant club wheat variety that was approved for release in February 1999. Efforts are continuing to develop new, more resistant varieties for the snow mold areas of Washington State. Research is in progress to develop methods of screening for resistance in the growth chambers to expedite the development of resistant varieties by allowing disease screening to continue throughout the year. Presently, field tests that rely on disease development under natural conditions are used to evaluate potential new varieties. During the winter of 2001-2002, snow cover persisted for just over 100 days across the northern wheat-producing region of Washington, which is the minimum length of snow cover required for development of snow mold. Consequently, snow mold pressure on our field plots was minor.

SPRING WHEAT BREEDING AND GENETICS

K. Kidwell, G. Shelton, V. DeMacon, M. McClendon, J. Smith, J. Baley and R. Higginbotham

The overall goal of wheat breeding efforts at WSU is to enhance the economic and environmental health of wheat production in the Pacific Northwest (PNW) by releasing genetically superior varieties for commercial production. Traditional breeding methods and molecular genetic technology are combined to reduce production risks associated with abiotic and biotic stresses by incorporating genetic insurance into adpated, elite varieties.

Over 300 crosses were made in 2001, and 27,217 breeding lines were evaluated in field trials at 1 to 16 locations in Washington State. Grain samples from 523 breeding lines with superior agronomic performance were sent to the USDA-ARS Western Wheat Quality Laboratory for end-use quality assessment. Efforts were initiated to proactively determine the risks of incorporating herbicide tolerant wheat into commercial production systems, specifically in terms of soilborne disease interactions. Specific objectives are to: 1) Measure the disease response of glyphosate-tolerant spring wheat to common soilborne pathogens after treatment with glyphosate; 2) Quantify the levels of key enzymes and aromatic products involved in disease defense, in glyphosate-tolerant and sensitive wheat challenged by soilborne fungal pathogens; and 3) Determine if glyphosate-sensitive grassy weeds or volunteer plants killed by applications of glyphosate within a crop of glyphosate-tolerant wheat can serve as a reservoir or green-bridge of inoculum, further increasing disease pressure on the crop. Risks associated with increased soilborne disease incidence may hinder widespread acceptance of conservation tillage systems for wheat involving herbicide resistance technology, thus eliminating the benefits of this strategy for reducing soil erosion, reducing fuel costs and improving soil quality. Efforts also are underway to screen wild relatives and synthetic wheat accessions for resistance to take-all and *Phythium,* two prevalent diseases in direct-seed wheat production, to identify potential gene donors for variety improvement.

Variety Pre-releases and Releases

A tall, hard red spring wheat (WA7859) was approved for pre-release in 2002. WA7859, tentatively named 'Hollis', is adapted to areas receiving less than 14 inches of average annual precipitation as a replacement for 'Scarlet'. Although Scarlet has performed well in the semi-arid region, it has relatively low test weight when stressed, and it is not an excessively tall variety. WA7859 is 3 to 4 inches taller than Scarlet and 'Butte 86' with above average grain yield potential, and higher test weight and grain protein content than Scarlet. WA7859 has excellent milling and baking quality, is early maturing and is resistant to stripe rust. WA7859 was rated as an exceptional bread making variety by the PNW Quality Council on 2002.

'Macon', a hard white spring was approved for release in 2002. Macon is a Hessian fly resistant variety with exceptional bread baking quality, acceptable noodle color and soft noodle texture. Registered seed of Macon will be increased in 2002. Several domestic milling and baking companies have expressed an interest in this variety on an identity preserved basis. Based on 2002 results from the Asian Collaborative sponsored by the Wheat Marketing Center in Portland, OR, Macon also has potential in export market for Japanese and Korean noodles.

'WA7902', an intermediate height spring club, tentatively named Eden, was approved for final release in 2002. The yield performance of this line equaled or exceeded that of the best soft white common entries in the 2001 variety testing trials across locations. Eden has excellent club quality, is early maturing and is resistant to stripe rust. Foundation seed of Eden will be produced in 2002.

Marker-Assisted Backcross Breeding

A wheat microsatellite marker associated with a chromosomal segment that confers a 1-2% grain protein content (GPC) increase in two donor lines, GluPro and ND683, was identified, then a strategy was developed to rapidly move this segment into adapted germplasm through marker-assisted backcross breeding. Initial crosses between the protein segment donor parents and the adapted hard red varieties Scarlet and Tara were made in 1998. The goal is to recover lines nearly identical to Scarlet and Tara with the addition of the increased GPC segment from the donor parents. BC_5F_3 lines, containing 99% of the genes from the WSU lines and 1% of the genes from the donor parents, including the high protein segment, were developed using this strategy, and this material was evaluated in the field in 2001. Grain protein content information has been collected, and we are in the process of confirming the presence of the high protein segment in this material. BC_5F_4 selections from 2001 will be advanced to 2002 field trials, and BC_6F_2 lines containing the high protein segment also will be evaluated in the field in 2002. Fertility trials designed to assess the nitrogen use efficiency of advanced breeding lines containing the high protein gene will be initiated in 2003.

Gene Discovery

Rhizoctonia root rot, caused by *Rhizoctonia solani* Kühn AG-8, is a yield limiting disease of direct-seeded cereal grains. Twenty-one adapted spring wheat (*Triticum aestivum* L.) genotypes from the U.S. Pacific Northwest were evaluated for two crop years in a split-plot field study with high and low levels of Rhizoctonia root rot. The "high" level consisted of inoculated soil and a host plant "green bridge" that was sprayed with a non-selective herbicide prior to planting. The "low" level was not inoculated and was kept plant free. Genotypes also were assayed for disease reaction in controlled environment (CE) assays. The objectives of this study were to (1) determine whether adapted spring wheat genotypes vary in susceptibility to Rhizoctonia root rot; and (2) evaluate whether disease ratings obtained by CE analyses are predictive of field disease ratings. Average disease ratings of field entries with high disease levels were significantly greater than those from the low level treatment ($P<0.05$). High disease levels also resulted in significant reductions in grain yield ($P<0.001$), plant height ($P<0.001$), heading date, ($P<0.05$) and grain protein content ($P<0.05$) compared to the low treatment; however, test weight was not affected by inoculum level. A statistically significant, negative association ($r=-0.6$, $P<0.0001$) between disease rating and grain yield was detected. Based on relative yield reductions, variation for reaction to *R. solani* exists among spring wheat germplasm from the PNW. Disease reaction differences were not detected among genotypes in CE assays, and field and CE disease ratings were not correlated ($r=0.23$, $P=0.32$) indicating that CE assays may not be prognostic of variety performance in response to Rhizoctonia root rot pressure in the field.

Transgene Assessment

Preliminary field trials were conducted in 2001 to compare the disease response of two herbicide tolerant wheat technologies and to evaluate the proposed experimental design scheduled for multiple locations in 2002-3. Natural weed populations were utilized in 2001 to provide any greenbridge disease transmission that occurred within the plots of RoundUp Ready®

and Clearfield® tolerant wheat. Rhizoctonia and Gaeumannomyces inoculated oats were added to the seed of near isogenic lines (NILs) at the time of planting, but no simulated volunteer wheat/barley or weed seeds were added. In order to better simulate greenbridge transmission of these pathogens, the appropriate inoculum and barley will be planted 7-10 days prior to planting the trial for 2002-3. The intention of these trials, besides identifying potential problematic pathogens in herbicide tolerant cropping systems, is to compare weed management strategies defined by novel tolerance of wheat to different herbicide chemistries. BASF had planned on launching Clearfield™ (imidazolinone) tolerant spring wheat in the next year or two, a schedule that would place it on the market before RoundUp Ready® spring wheat. But, we were notified that crop damage had occurred due to herbicide application when these lines were grown under actual production practices. For this reason BASF has postponed the release of this technology until alternate spring wheat lines tolerant to imidazolinone herbicides are available for breeders. Apparently the damage experienced with spring wheat lines has not been seen with the winter wheat lines that have been developed. But, the removal of Clearfield™ spring wheat has meant that this study will now focus solely on glyphosate tolerant spring wheat. To minimize varietal differences, we have obtained multiple adapted glyphosate tolerant lines for 2002-3 field trials.

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EFFECTS OF CL FERTILIZATION ON YIELD, PROTEIN AND FLOUR QUALITY OF FOUR SPRING WHEAT CULTIVARS

G.J. Schwab, J.W. Burns, and K.K. Kidwell

Chloride deficiency of wheat is generally observed in areas where KCl fertilizer is not commonly used (because of high soil K levels). Chloride deficiency symptoms in wheat consist of leaf spotting (commonly referred to as physiological leaf spot) and each wheat variety differs in its ability to tolerate low Cl soil. Research in the north central and northwest regions of the U.S. and across Canada have shown yield increases of up to 20% with the addition of 20 lbs of Cl per acre. In eastern WA, soils are high in K and are therefore very low Cl. Recent cultivar releases ('Zak' soft white and 'Tara' hard red) exhibit relatively more leaf spotting compared to the older varieties ('Alpowa' and 'Westbred 926'). In the inland Pacific Northwest, the potential for increased profitability from Cl fertilization of spring wheat is great, but no research has been conducted to determine which spring wheat cultivars respond to Cl fertilization. This study is designed to determine the chloride responsiveness of hard red and soft white spring wheat grown in the PNW. The goal of the research team is to provide growers with variety specific nutrient recommendations as each new variety is publicly released.

Procedures

The experiment was conducted in the high (20-24 inches) rainfall zone of eastern Washington using a split plot design. Four wheat cultivars were the whole plot and four Cl rates were the sub plots. Whole plots were 5.5' x 80' and were 5.5' x 20'. The study consisted of four replications, and statistically analyzed for a split plot design with a critical level of 0.10. Treatment means were separated with Fisher's protected LSD ($p<0.10$) when significantly different.

Two hard red cultivars Westbred 926 and Tara and two soft white cultivars Alpowa and Zak were used in this study. Westbred 926 and Alpowa have been selected because they are the major hard and soft cultivars grown in eastern WA. Tara and Zak are cultivars that will be released by WSU within the next three years, and will hopefully replace the older varieties. Chloride rates of 0, 10, 20, and 40 lbs a^{-1} were applied as KCl in the deep band (2.5 inches below the seed) at planting. Check plots received an equal rate of K as KNO_3. Ammonium phosphate sulfate (16-20-0-14) was applied as a starter (seed placed) at a rate of 50 lbs a^{-1} and 50 lbs a^{-1} was also applied in the deep band (100 lbs total). The remainder of the N was applied as urea in the deep band. The two soft wheat cultivars received a total of 100 lbs N a^{-1} while the hard red wheat received 180 lbs N a^{-1} to achieve protein goals. Sites selected had less than 20 lbs a^{-1} of available Cl in the surface two feet and had 100 lbs of residual N in the surface four feet.

Whole plant samples were collected at head emergence for the drymatter determination and Cl uptake. At physiological maturity, a plot combine was used to harvest a four-foot-wide strip from the center of each plot for yield determination. A subsample of grain was retained for moisture, test weight, kernel weight, protein analysis, and Cl analysis. Protein was determined using a LECO CNS2000 and Cl was determined using a potentiometric titration. Flour, milling, protein, and baking qualities of the grain harvested from all plots will be determined and reported at a later date.

Results

Due to poor plant emergence Alpowa soft white wheat was dropped from the study. There was no significant chloride rate effect on dry matter accumulation for plants sampled at the head emergence stage for any cultivar. Chloride rate did, however, significantly increase tissue Cl concentration of the three cultivars at this growth stage. Tissue concentration of the check plots and the 10 lb Cl a^{-1} plots were below the established critical level of 0.1% (Fig 1). None of the plants in this study showed leaf spotting consistent with Cl deficiency even though the tissue Cl concentrations where extremely low.

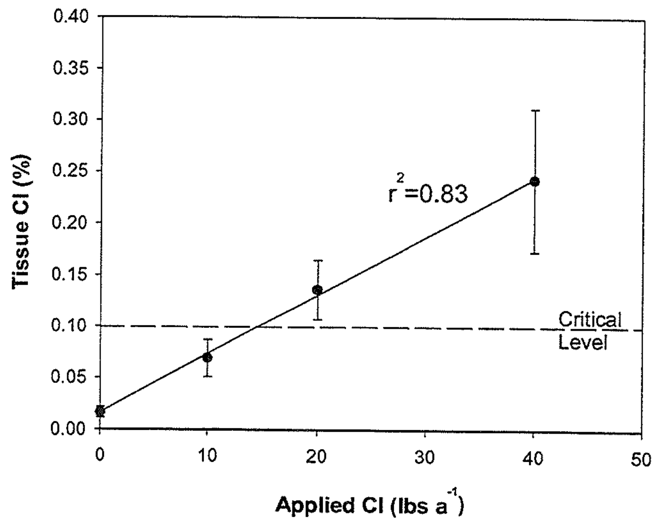

Figure 1. Average tissue chloride concentration at head emergence (Feekes 10.1).

There was a significant cultivar by chloride rate interaction for grain yield. The hard red spring wheat WB 926 had no yield response to chloride while the other hard red Tara and the soft white Zak had significant positive yield response to 10 and 20 lb Cl a^{-1}, respectively (Fig 2). Application of additional rates of Cl for these two cultivars significantly reduced yield compared to the maximum. This observed yield decline cannot be explained and was not visually apparent prior to harvest.

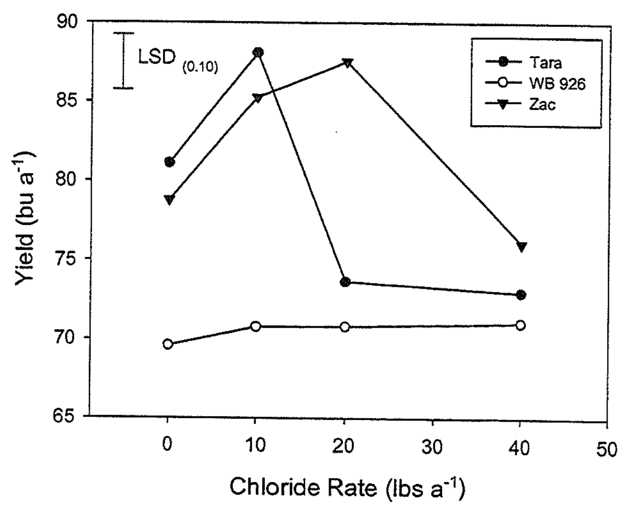

Figure 2: Chloride effects on grain yield for the three cultivars of spring wheat. LSD is for comparing any two points.

There were no significant Cl rate effects on grain protein, but there was a significant cultivar effect (Fig 3). Because of the lower protein requirements for soft spring wheat, Zak was fertilized with less N. The protein goal for the two hard red cultivars was 14%. Because of better than expected rainfall, we underestimated the yield potential of the hard red cultivars and did not apply enough N to achieve our 14% protein goal.

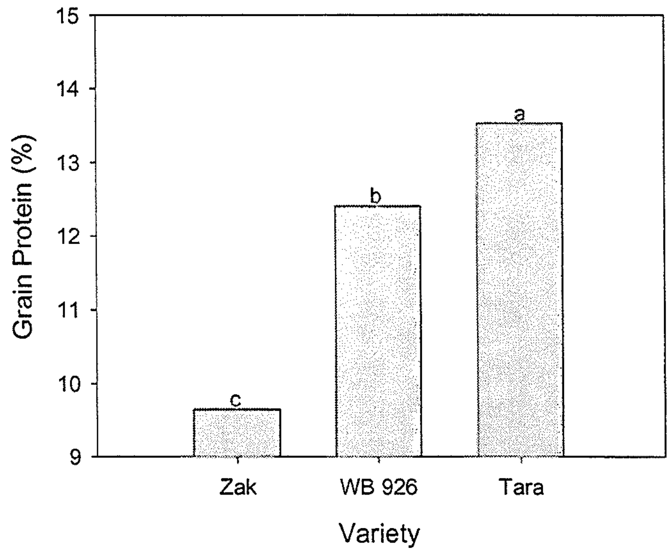

Figure 3. Cultivar effects on grain protein. Bars with different letters are significant ($p<0.10$).

Conclusions

The newly released cultivars Tara and Zak seem to have a greater yield response to Cl fertilization compared to the more widely grown WB 926. Both new cultivars showed an unexplained significant yield decline for excess Cl fertilization. Growers considering these two cultivars should apply 10 to 20 lbs Cl a^{-1} to achieve maximum yield. Chloride fertilization increases yield potential which must be considered when making N fertilizer recommendations. For each additional 1 bu/a increase in yield potential, 2.5 and 3.7 lbs addition N is required for soft white and hard red varieties, respectively. This study will be repeated in 2002 at Pullman and Dusty, WA, to test for Cl response under different growing conditions. Flour samples are still being analyzed to determine Cl effects on baking quality. These results will be reported when they become available.

CONTROL OF WHEAT AND BARLEY RUSTS
2001 PROGRESS REPORT

X.M. Chen, M.K. Moore, D.A. Wood, and R.F. Line

OVERVIEW: Stripe rust, leaf rust, and stem rust affect all classes and types of wheat and occur in all agronomic zones. Without resistance, all winter and spring wheat in the Pacific Northwest (PNW) can be infected. The rusts are most destructive in the high rainfall and irrigated zones. **Stripe rust** is the most important disease of wheat in the PNW and has become increasingly important in the south central states and the Great Plains. The PNW environment is highly favorable for severe stripe rust (losses in excess of 20%) in at least three out of four years and every year in western Washington. In the PNW, stripe rust reduced wheat yields by more than 50% in the early 1960's and by more than 20% in 1981. Without resistant cultivars and effective fungicides, losses would often exceed 80%. The destructiveness of **leaf rust** occurs in at least two out of every four years and every year in fields with overhead irrigation. As we improve stripe rust resistance, leaf rust becomes more important because wheat crops not damaged by the early stripe rust can be damaged by leaf rust. Losses of 10 to 50% caused by leaf rust have occurred in many years since 1974. Leaf rust is more severe when the weather is most favorable for high yields. **Stem rust** is less common because it develops late in the growing season when the weather is often unfavorable for the rust. When precipitation is frequent in June and July, it can cause greater losses than stripe rust. Except for a few winter wheat cultivars and some spring wheat cultivars, wheat cultivars grown in the PNW are generally susceptible to stem rust. **Barley stripe rust** is a relatively new disease that can cause widespread damage to barley. Barley stripe rust and wheat stripe rust are similar; however, they are two different diseases. Wheat stripe rust can attack some barley cultivars, but it has never severely damaged the barley crop. In contrast, barley stripe rust has reduced barley yields by 30 to 100 percent and reduced grain quality. In the United States, barley stripe rust was first detected in Texas in 1991, and is now established in the western United States. The environment in the PNW is highly favorable for barley stripe rust. If not controlled, it can be highly destructive whenever the weather is favorable for epidemics.

GOAL: Prevent losses in yield and quality of wheat caused by stripe rust, leaf rust, and stem rust and of barley caused by stripe rust, and assure stable, sustainable wheat and barley production.

APPROACH: Monitoring rusts, determining environmental and managerial factors that contribute to rust epidemics, identifying races, and characterizing rust populations; characterizing types, identifying new sources, determining inheritance, and identifying new genes of resistance; screening for resistant germplasm and testing breeding lines for new cultivars with adequate rust resistance; developing strategies and methods to improve resistance, developing molecular markers for resistance genes, and using the markers to combine genes for different types of resistance to obtain durable and high-level resistance; and determining effectiveness and use of fungicides for rust control.

ACCOMPLISHMENTS:

1. Monitored rust development, predicted rust epidemics, assessed crop losses, determined prevalent races, and identified new races

Rusts of wheat and barley were monitored throughout Washington State using trap plots and field surveys. The diseases were accurately predicted for the PNW in 2001 using monitoring data and predictive models based on environmental factors such as temperature, precipitation, and resistance of wheat cultivars. Through cooperators in many other states, stripe rusts of wheat and barley were monitored throughout the U.S. In 2001, wheat stripe rust occurred from California and the PNW to Georgia and Virginia; and from Louisiana and Texas to North Dakota and Minnesota. Severe yield losses caused by stripe rust occurred in fields of susceptible wheat in the PNW, California, Colorado, Texas, and especially Kansans. Kansas had wheat losses of about 26 million bushels and the total yield loss of wheat caused by stripe rust in the U.S. was estimated over 39 million bushels in 2001. The epidemics in the Great Plains were due to the weather conditions, new races of the stripe rust pathogen, and widely grown susceptible cultivars.

In the PNW, wheat stripe rust occurred widely, but yield losses were low (about 1.6 million bushels) in 2001. The winter of 2000-2001 was mild, favoring stripe rust overwintering. More than 90% stripe rust was observed on susceptible entries in our stripe rust nurseries and on susceptible cultivars such as "Westbred 470" in commercial fields. Resistant cultivars that were widely grown in the PNW provided effective control of wheat stripe rust. The durable, high-temperature, adult-plant resistance that is in most soft white winter wheats, hard red winter wheats, and spring wheats and the multiline cultivar 'Rely' of club wheat with many seedling-resistance genes prevented stripe rust epidemics.

Wheat leaf rust occurred in some locations, but generally in lower levels because of unfavorable conditions. Yield losses due to leaf rust were the minimum. Wheat stem rust occurred in the later growing season in the PNW in 2001 and caused significant losses in some fields. The soft white winter wheat cultivar 'Madsen' had moderate levels of stem rust.

Barley stripe rust continued surviving and developing in the U.S. and caused localized epidemics in 2001. The rust occurred mainly in Texas, California, and Washington. Severe stripe rust occurred in the central valley of California and northwestern Washington. In eastern Washington, stripe rust was found in almost every barley field that was surveyed, although the disease level was generally low.

Hundreds of stripe rust collections from wheat and barley were evaluated to determine their virulence. Wheat stripe rust samples were increased on susceptible cultivars and tested on a set of 20 cultivars that are used to differentiate races of wheat stripe rust in the U.S. In 2001, the most prevalent races in the PNW were those virulent on Lemhi, Fielder, Produra, *Yr8*, *Yr9*, and seedlings of Druchamp and Stephens. The most prevalent races in California were virulent on Lemhi, Chinese 166, Heines VII, Lee, Fielder, and seedlings of Express. The predominant races east of the Rocky Mountains were those virulent on Lemhi, Heines VII, Produra, Lee, Fielder, *Yr8*, *Yr9*, and seedlings of Express. Races with new combinations of virulences were identified in 2001. Barley stripe rust samples were tested on 12 barley varieties that are used to differentiate races of the barley stripe rust pathogen. At least four new races were identified. These new races are virulent on seedlings of 'Bancroft', one of the first U.S. barley varieties developed for resistance to barley stripe rust. The races virulent to Bancroft were detected from

Texas, California, and Washington. Even though the level of Bancroft virulent races was generally low, the races were widely distributed in Washington in 2001.

2. Tested germplasm and breeding lines for rust resistance

In 2001, more than 10,000 entries of wheat and barley germplasm, breeding lines, and varieties from the National Germplasm Collection Center and wheat and barley breeders in the western U.S. were evaluated in the greenhouse and fields for resistance to the most virulence races of the stripe rust pathogens of wheat and barley and/or at field sites for adult-plant resistance. Germplasm and breeding lines with resistance to the rusts were identified. High-temperature, adult-plant (HTAP) resistance continues being the most effective and durable type of resistance against wheat stripe rust. More than 95% of the wheat cultivars grown in Washington have stripe rust resistance, and all newly released varieties have HTAP resistance. The rust data were provided to breeders for selection of breeding lines with stripe rust resistance. HTAP resistance, which has been successfully used in wheat for control of wheat stripe rust, has been identified in barley. In a greenhouse experiment using barley stripe rust isolates to test both seedlings and adult-plants of Bancroft and Steptoe at both high and low temperatures, Bancroft showed clear HTAP resistance against isolates from Texas, California, and Washington. The HTAP resistance in Bancroft is non race-specific and may be durable.

We have identified 28 genes for stripe rust resistance in 18 barley genetic stocks. In collaboration with Dr. Hayes of Oregon State University and Dr. Kleinhofs of Washington State University, we also identified several quantitative trait loci for stripe rust resistance in 'Shyri' and 'Gobernadora'. We developed molecular markers for some of the genes. Many of the genes are currently used for developing varieties with stripe rust resistance. Because of most of the genetic stocks are not agriculturally adapted, we are developing resistant germplasm from our genetic studies using a backcrossing approach. It should be easier for breeders to use the improved germplasm than the original germplasm for developing resistant cultivars.

Because barley is generally resistant to wheat stripe rust (the wheat form) and wheat is resistant to barley stripe rust (the barley form), genes in wheat conferring resistance to the barley form could be transferred into barley for control of barley stripe rust and verse visa. Research has been conducted to determine the genetic bases and identify genes in barley for resistance to wheat stripe rust and genes in wheat for resistance to barley stripe rust. Barley crosses and wheat crosses were made in the greenhouse. F_1, F_2, and backcross seed were obtained for the crosses. F_2 plants are now grown in the field and greenhouse for obtaining F_3 seed for determining the genetics of resistance and mapping of the resistance genes.

3. Developed molecular markers for stripe rust resistance

To obtain superior, durable resistance against stripe rust of wheat, molecular markers were identified for genes conferring high-level seedling resistance, and durable, adult-plant resistance. The resistance gene analog polymorphism (RGAP) technique that we recently developed was used to identify markers for wheat resistance to stripe rust. Using the RGAP technique, we have developed molecular markers for *Yr9*, *Yr5* and *Yr15*. The *Yr9* markers have been published and used to determine the presence of *Yr9* in wheat germplasm. Of 16 RGAP markers identified for *Yr5*, six markers were completely associated with the *Yr5* loci. Through cloning, sequencing and data searching, we identified RGAP markers with high homology with many plant resistance genes. The results indicate that the molecular markers may be part of the *Yr5* resistance gene. Based on the DNA sequences, we have designed 16 sequence tagged site (STS) primers. Most of the STS primer combinations differentiated the *Yr5* resistance gene from its susceptible forms. Five STS markers amplified with three pairs of the STS primers were also completely associated with the *Yr5* locus. These STS markers were more specific and easy to use for incorporating the *Yr5* resistance gene into commercial cultivars. We identified 12 RGAP markers for the *Yr15* resistance gene. Several of the markers were tightly linked to *Yr15* and one marker completely associated with the *Yr15* resistance. We used the *Yr15* markers correctly checked the presence and absence of the resistance gene in some breeding lines. These results show that the RGAP technique can be used to identify resistance genes in germplasm and the molecular markers should be useful for combining resistance genes. These markers are currently used to combine different genes for durable and superior resistance.

4. Determined effectiveness and use of foliar fungicides for rust control
When susceptible cultivars are grown and environment is favorable for rusts, fungicides can be used to reduce yield loss. In 2001, we tested effectiveness of several fungicides to control wheat and barley rusts in the field plots near Mt. Vernon and Pullman, WA. Foliar applications of Quadris, Tilt, Folicur, and Stratego effectively reduced stripe rust of wheat and barley. Use of mixtures of Tilt and Quadris also controlled rusts. Quadris was the best fungicide for control of barley stripe rust in the tests of both 2000 and 2001.

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WASHINGTON STATE UNIVERSITY WHEAT QUALITY PROGRAM

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Cooperators: Steve Jones, Kim Kidwell, Kim Campbell, and Craig Morris

The goal of the Washington State University Wheat Quality Program (WSUWQP) is to increase the competitiveness of Washington wheat in the global market by developing and promoting agronomically superior varieties that also possess desirable end-use quality characteristics. The WSUWQP was created in 2000 as part of the safe food initiative to address losses in global market share by U.S. wheat due to inferior wheat quality.

WSU Breeder Line Evaluation

In 2001, the WSUWQP, in cooperation with the Western Wheat Quality Lab, analyzed over 5000 Washington breeder lines and completed all testing on crop year 2000 material by June 1. Several delays were avoided due to the WSUWQP eliminating bottlenecks in the quality testing process. Brady Carter of WSUWQP also met with the breeding programs to discuss quality testing results for crop year 2000, to assist in making selections, and to plan quality testing for crop year 2001. In addition, the WSUWQP has been in constant communication with the breeders to provide updates on testing progress and address efficiency issues as they arise. The cooperative relationship that has been developed between the WSUWQP and the Western Wheat Quality Lab is responsible for the increased efficiency in evaluating breeder lines. This relationship has allowed the WSUWQP to address bottlenecks when they arise by adjusting work schedules to include testing that has fallen behind. The increased efficiency facilitated the completion of quality testing on several Winter wheat nurseries before 2001 planting and the completion of quality testing on the 2001 Spring wheat crop a month ahead of schedule. The WSUWQP also has been involved in early generation testing for all breeding programs including performing such tests as SRC, SDS Seds, single kernel analysis, and protein. Most importantly, the WSUWQP has been able to adapt to the quality testing needs of each breeder to provide a personalized testing service specific to the needs of each breeder.

New Quality Testing Procedures

The WSUWQP also has been working to develop new testing procedures that will increase the effectiveness and efficiency of the quality testing process. For instance, the data needed to establish solvent retention capacity (SRC) profiles appropriate for evaluating breeder lines has been collected and is currently being analyzed. However, since the importance of several key SRC solvents is already known, data generated using these solvents can be utilized for quality assessment immediately without established SRC profiles. Consequently, the methodology for using the SRC test to evaluate breeder lines has been successfully established and is currently being utilized. In addition, work has begun to establish a protocol for testing Asian noodle texture. The issue is whether to work with yellow alkaline noodles or Chinese raw noodles. An experimental plan has been established to determine the most appropriate noodle type and implement a protocol for testing noodle texture at WSU.

Market Development

The WSUWQP has established lines of communication with wheat markets, both domestic and foreign, through meetings and personal visits. The PNW Quality Council meeting and the Hard White Wheat meeting are examples of meetings attended by the WSUWQP to explore the marketability of WSU wheat varieties in the domestic market. In addition, cooperative efforts with the breeders have resulted in a high level of interest by the industry in several new varieties and efforts are underway to develop a system where these varieties can be grown under contract and delivered identity preserved to specific industries.

Efforts also are being made to establish communication with representatives of foreign markets to discuss the quality attributes they consider most desirable in the wheat they purchase. A system has been established that utilizes the U.S. Wheat Associates' Asian Collaborative to allow representatives of foreign markets to assess the quality of WSU varieties prior to release. The WSUWQP is working to broaden the system to include intense market specific end-product testing by the Wheat Marketing Center on larger groups of varieties prior to submittal to the Asian Collaborative. Only varieties with superior performance will be submitted to the collaborative, such that foreign customers evaluate only those varieties showing the greatest potential. Brady Carter recently visited Asia as part of the U.S. Wheat quality improvement team and collected valuable information concerning the quality attributes most desired by the Asian customers.

Extension

The WSUWQP has worked hard to establish lines of communication with growers of the state to become their extension source for quality information. We have made presentations at numerous grower meetings and field days to promote planting for quantity and quality. We also have cooperated with the Western Wheat Quality Lab on the development of quality scores for released varieties as part of the G and E project. Education on the intrinsic values of the various wheat varieties is extremely important and will enable growers to be successful as markets continue to become more quality oriented and driven by private contracts.

Final Thoughts

In the global market, wheat buyers have imposed tighter quality specifications and are demanding wheat varieties that possess flour functionality characteristics that ideally suit them for use in specific products. The current wheat marketing system in the U.S. allows wheat varieties of the same market class with variable functionality to be grouped together with no penalty for low quality. The result is a lack of consistency in the quality of U.S. wheat. By developing new varieties that are agronomically superior, as well as superior for quality, the WSU breeding programs, in cooperation with the WSUWQP, can help eliminate the lack of consistency at no risk to the grower. When the highest yielding varieties also are the highest quality varieties, the grower doesn't have to choose between quality and yield. Domestic and foreign markets will continue to demand increased quality consistency and the future success of the wheat industry in Washington depends on cooperation by the researcher, grower, and end-user to produce a wheat crop that requires less input and possesses superior, consistent end-use quality.

BARLEY IMPROVEMENT RESEARCH

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Collaborators: A. Kleinhofs, D. von Wettstein, J.W. Burns, P.E. Reisenauer, J. Kuehner, R.J. Cook, R.L. Line, X. Chen, and B.-K. Baik

The overall goal of the WSU Barley Improvement Program is to make barley a more profitable crop. Specific objectives are to improve agronomic and grain quality factors and pest (disease and insect) resistance for dryland and irrigated production. The emphasis is on spring hulled barley with additional efforts on spring hulless and/or waxy, and winter types. **New two-row spring cultivars were released in each of 2001 (Farmington) and 2002 (Bob), an additional line is anticipated for release in 2003 (98NZ223 or 98NZ015).**

Variety Releases

The latest release (2002) from the Barley Improvement Program is the new two-row spring feed barley 'Bob'. It is a selection from A-308 (Lewis somaclonal line) / Baronesse cross. Lewis is a two-row spring feed/malting variety; Baronesse is a leading two-row feed variety grown in Washington State. Bob (tested under designation WA8682-96) has wide adaptation in eastern Washington, and represents a public variety that appears to have yields equivalent or higher than Baronesse in many locations across eastern Washington. Additionally, this cultivar has the potential to be designated a malting cultivar, and it has a higher level of resistance to barley stripe rust than Baronesse. It has broader adaptation than Farmington (released in 2001), which is specifically adapted to mid to high rainfall areas and under irrigation. Bob yielded statistically equal or higher than Baronesse in 13 of 15 testing site over two years in the Extension State Uniform Nursery (Table 1). Foundation seed of Bob will be produced in 2002. A full description of the cultivar Bob was published in the June 2002 issue of *Wheat Life*.

Another current release is the two-row spring feed barley cultivar Farmington (released in 2001). It is a semi-dwarf selection from the cross WA7190-86 / Maresi. Maresi is a European two-row malting type. WA7190-90 is from the cross: WA10698-76 (Klages / WA8189-69) / WA8517-74 (Piroline Semi-dwarf Mutant / Valticky Semi-dwarf Mutant). Farmington was tested as WA9504-94. It is adapted to the mid to high rainfall areas of eastern Washington (Table 1.) and has partial resistance or tolerance to barley stripe rust (BSR) based on tests in Bolivia, Mexico, California, and western and eastern Washington State. It is expected to compete with Baronesse in some areas in eastern Washington and with other recently released BSR resistant cultivars. It has potential malting quality based on micro-malt data, but needs further testing on the pilot scale level. Registered seed of Farmington will be produced in 2002. A description of Farmington was published in the May 2001 issue of *Wheat Life*.

Two new proanthocyanidin-free two-row lines bred collaboratively with Diter von Wettstein were approved for pre-release Breeders seed increase in 2002. These lines, 98NZ223 and 98NZ015, were derived from proanthocyanidin-free mutant or cultivar by Baronesse crosses. They have high yield potential equal to Baronesse averaged over two years of testing in the

Extension State Uniform Nursery (Table 1). They have relatively good malting quality, as well, especially 98NZ223. Preliminary screening indicates that 98NZ223 may have Hessian fly resistance equal to Baronesse.

Cultivar Development

Over 140 spring barley crosses were made in 2001. There were 50 F_2 populations and 120 F_3 single-seed descent populations grown in the greenhouse. Lines were selected from approximately 13,500 head rows (150 families). There were approximately 1,300 single replication evaluation plots planted at Spillman Farm in 2001; the entries of which came from 2000 or 2000-2001 (New Zealand) head/plant rows. The more advanced lines are tested in thirty-five major yield trials at Spillman Farm and throughout eastern Washington, including a preliminary state yield trial grown at three locations – Pullman, Royal Slope, and Ritzville – and the Extension State Uniform Nursery planted at 15 locations (nine extension/Burns, Reisenauer, Kuehner). Barley performance in 2001 was presented in the Jan. 2001 *Wheat Life*. There were seven grower-conducted on-farm tests with six entries (including Farmington) in Columbia, Garfield, Asotin, and Whitman counties in 2001 coordinated by Kevin Anderson of Great Western Malting Company and Roland Schirman and John Burns, of Cooperative Extension. The highest yielding varieties were Farmington (3813 lb/a) and Legacy (3852 lb/a), which were essentially equal and 107 and109% of Baronesse (3539 lb/a), respectively.

Grain quality evaluations of breeding lines and cultivars are conducted on field-grown samples. Basic kernel quality characteristics, such as test weight and kernel plump-thin percentages, are measured in our laboratory. Malting quality is evaluated at the USDA-ARS Cereal Crops Research Unit at Madison, Wisconsin. A set of samples consisting of 24 varieties grown in three locations was provided for a study aimed at examination of barley flour and barley product color and discoloration. This project is partially funded by the Washington Barley Commission and led by Dr. Byung-Kee Baik, Dept. of Food Science and Human Nutrition. Color is an important sensory quality component for foods, and this work could lead to new barley breeding selection criteria and better acceptance of barley as a human food component. Collaboration on this project will continue in the future.

Disease and Insect Resistance

While yield and grain quality are always important selection criteria, pest resistance remains a high priority. Crossing, screening and selection for Russian wheat aphid, barley stripe rust, soil borne pathogens, and Hessian fly resistance is underway. The **Russian wheat aphid** is a relatively new pest in the Pacific Northwest (PNW) and has the potential to inflict serious damage to the barley crop. Reaction screening is carried out at the USDA-ARS Insect Laboratory at Stillwater, Oklahoma. Resistant germplasm developed in WSU as well as other western material will be evaluated in 2002. **Barley stripe rust** (BSR) is a new disease to the PNW and little resistance exists in currently grown barley cultivars. Rollie Line has and Xianming Chen is currently collaborating on monitoring and testing for this disease. We have had germplasm screened for barley strip rust reaction the past several years in Bolivia, Peru, Colorado, California, Mexico, and/or Washington. There appears to be good resistance in a relatively large number of WSU breeding lines including Farmington (WA9504-94) and Bob

(WA8682-96) described above. A new backcross program to incorporate various sources of resistance into PNW adapted cultivars and lines was initiated in 2001 with Xianming Chen. **Soilborne pathogens** probably affect barley production more than we realize especially in reduced tillage cropping systems. Efforts were initiation in 1994 in collaboration with Jim Cook to screen for reaction to soilborne pathogens in the field and growth chamber. Field testing for soilborne pathogen reaction has been expanding over the past few years with nurseries planted variously at Spillman Farm, Dusty, Ralston, Ritzville, Bickelton, and most recently at the WSU Cunningham Farm. Carolyn (Kruger) Wesselius' M.S. thesis research focused on direct-seeded barley and soil-borne disease reactions in the field and growth chamber. She found partial resistance or tolerance in several lines evaluated in the field or growth chamber. Backcross breeding projects are underway for Russian wheat aphid, barley stripe rust, and *Rhizoctonia* resistance. Backcross progeny will be screened with molecular markers linked to the stripe rust resistance genes. New collaboration was begun in 1999 for screening barley germplasm for **Hessian fly** resistance at the USDA-ARS Insect Laboratory at Purdue University, West Lafayette, IN. Several lines have been identified that have at least partial resistance to this insect pest. Hessian fly in barley seems to be a persistent and growing pest problem as reduced tillage production increases.

Application of Biotechnology

Collaboration in the North American Barley Genome Project involves work on several fronts with Andy Kleinhofs and others. The comprehensive genome map developed from Steptoe/Morex is being applied to quantitative trait locus (QTL) analysis and molecular marker assisted selection relevant to cultivar development. We are verifying QTLs identified and developing molecular marker assisted selection strategies for use in the breeding program. Initially, we are concentrating on the dormancy trait and yield from Steptoe, several malting quality traits from Morex, and barley stripe rust resistance from several sources. Mapping populations from the Harrington/TR306 and Harrington/Morex crosses have also been evaluated. The incorporation of yield QTL from Baronesse into Harrington is a collaborative project with Andy Kleinhofs, Dave Kudrna, and Deric Schmierer, a M.S. student. A number of lines seem to have high yield combined with good malting quality. After preliminary yield testing, five Harrington / Baronesse backcross lines were entered in the Extension State Uniform Nursery in 2002. The availability of a detailed genome map allows us to begin to understand the genetics of complex economically important agronomic (yield, lodging, maturity) and quality (kernel, feed, malting) traits through QTL analysis. With the identification and location of specific genes, marker-assisted selection strategies can be developed for more directed breeding.

Table 1. 2000-2001 Spring Barley Performance Extension State Uniform Nursery (%Baronesse).

VARIETY	ANATONE	WALLA[2]	BICKLETON	RITZVILLE	MAYVIEW	LAMONT	ALMIRA	DAYTON	ST. JOHN	DUSTY	FAIRFIELD	FARMINGTON	REARDAN	PULLMAN	ROYAL SLOPE	26 SITE / YEAR MEAN
Bob	100	105	123	109*	96	94	96	87*	100	95	96	101	100	90*	103	98
98NZ223	92	93	123	102	99	108	99	97	104	98	97	98	100	103	97	100
98NZ015	69*	72*	119	109*	104	97	90	91*	97	93	98	102	97	96	115*	98
Farmington	81*	100	87	90*	99	82*	114*	91*	100	86*	91*	105	98	95*	111*	96*
Harrington	88*	105	72*	85*	88*	86*	103	84*	94	101	87*	101	91*	92*	100	93*
Baronesse	1972	2944	2609	3669	3919	4551	4056	4357	4254	4429	5894	5595	5967	6798	6596	4690
Loc. Mean	1846	2780	2841	3552	3662	3814	3893	3968	4030	4031	5284	5352	5660	6396	6806	4414
		1	2	2			1									

1 – 2001 data only; 2 – 2000 data only; * - Indicates significant difference from Baronesse, alpha = 0.10.

THE BARLEY BREEDING ACTIVITIES OF THE R.A. NILAN PROFESSORSHIP

Diter von Wettstein

A main challenge for agriculture in this century is to sustain and increase food, feed and commodity productions without degrading the environment. Yields in bushels per acre have been steadily increasing over the last century and economists estimate this to result equally from improved and better adapted cultivars obtained by plant breeding and from improvements in crop cultivation technologies. As to the latter the advances reported on developing direct-seed cropping systems to conserve water and avoid soil erosion are primarily made possible by newly developed machinery for large scale farming in the form of plot drills that can place fertilizer and seed in single pass operations and by the plant residue management wheel preventing plugging of the drill and pile-up of residues behind the planter. But, advances in cropping systems create new challenges to the barley and wheat geneticists and breeders. Fungal, bacterial and insect diseases are facilitated when the crop residues are retained on the surface of the soil as is development of the green bridge consisting of volunteer seedlings emerging after harvest and remaining over the winter. They are now combated with round-up treatment, which may not be possible as round-up resistant barley and wheat varieties emerge. Additionally, retaining more plant residues on the soil is likely to increase accumulation of organic phosphate, especially phytate in the soil. Phytate is presently unusable by barley and wheat roots and is a major pollutant of ground and river water. But, we are fortunate that we now have an additional tool in the form of genetic engineering to breed novel cultivars. Accordingly our barley-breeding program is two-legged. With one leg we breed for barley with high yield stability and novel quality by recombination and mutation breeding methods, with the other we employ genetic engineering for creating improved barley plants.

High yielding proanthocyanidin-free barley 98-NZ223; Proposed name: Calypso

Proanthocyanidin-free barley is a quality improved raw material for the malting and brewing industry because it insures an excellent haze stability of the beer. But, proanthocyanidin-free barley is also excellent as feed barley, as shown by broiler chicken trials [von Wettstein *et al.* MBAA Techn. Quarterly *22*,41(1985)] and by researchers in Canada, where diets for finishing beef cattle normally comprise 80% or more dry-rolled barley grain [Wang *et al.* 1999]. Line 98-NZ223 was developed with a sodium azide induced mutation in the variety Harrington. It blocks the last steps in the synthesis of proanthocyanidins and was crossed with the variety Baronesse. Proanthocyanidins, also known as condensed tannins, are polyphenolic compounds that bind strongly to proteins and carbohydrates. Proanthocyanidins are colorless, but their name indicates that they are related to the red, blue or orange anthocyanin pigments in flowers. In barley proanthocyanidins are formed exclusively in the seed coat (testa) of the grain and they can be stained red with vanillin in the mature grain. This provides a practical test to distinguish proanthocyanidin-free barley from barley containing proanthocyanidins. Proanthocyanidins survive the malting process, are dissolved during the mashing procedure in the wort and land up in the beer produced by fermentation with yeast. There they will precipitate proteins and carbohydrates especially under low temperature conditions. This is known to brewers as permanent and chill haze. Therefore any brewery that wishes to serve and sell brilliant clear beer with good shelf-life has to remove the proanthocyanidins by technical procedures prior to bottling or canning of beer. Full scale brewing with proanthocyanidin-free barley produces beer without permanent or chill haze, thus making the technical stabilization procedures superfluous. Some brewers like to use mixtures of barley varieties. In that case it is to be observed that 50% proanthocyanidin-free barley in mixtures with proanthocyanidin containing barley provide the same chill-haze stability as achieved by presently used technical procedures [von Wettstein *et al.* MBAA Techn.Quarterly *17*,16 (1980)]. Development of proanthocyanidin-free barley is based on clarifying the biochemical genetics of proanthocyanidin synthesis with the aid of induced mutants, determining the enzymatic steps at which the synthesis can be blocked without penalty to yield and disease resistance, pilot and full scale malting and brewing (5000hl) trials and taste panel evaluations that proanthocyanidins in contrast to brewers, lore have no influence on beer taste. An important lesson learned with this project was that without competitive yield, such a barley, although highly desired by maltsters and brewers, has no chance in the market. Calypso, having also other good malting quality traits, now has a chance. It is equally suitable for feed and might replace Baronesse, which lacks malting quality.

After 21 years of efforts, with forceful input by Bob Nilan, Judy Cochran and shifting barley crews, it has now been possible to select a proanthocyanidin-free barley variety that is equal in yield to Baronesse. Baronesse yielded on the average at 13 locations of the State Uniform Nursery 5269 LBS/A in the year 2000. The average yield of 98NZ 223 was 5322 LBS/A; that is 1% more than Baronesse. In 2001, the average yield of 98NZ 223 was 1% below Baronesse. Considering the two-year average, we conclude that the two cultivars have the same yield capacity. Malting quality of 98NZ 223 [Calypso] as determined by AMBA (CCRU) is of the same level as Harrington, if the barley is grown under suitable nitrogen limiting conditions. In the current year, 98NZ223 is propagated on land suitable for producing grain with high malting quality for further micro-malting tests and a full-scale malting in a commercial plant is planned for 2003.

Improved barley broiler feed with transgenic malt or grain containing a protein-engineered heat-stable (1,3-1,4)-β-glucanase.

This product is ready to be marketed and was developed at WSU over the last 5 years. It comprised the following steps:

[i] A routine procedure to generate gene transfer by co-cultivation of immature zygotic barley embryos with *Agrobacterium* was established permitting transgenic plants to be regenerated via somatic embryos formed by callus of transformed scutellum cells.

[ii] Transgenic plants have been obtained that synthesize during malting or during grain maturation one of the following recombinant proteins: thermotolerant (1,3-1,4)-β-glucanase, human antithrombin III, α_1-antitrypsin, lactoferrin, lysozyme and serum albumin. Tissue specific expression during malting is provided with the promoter of the gene for an aleurone specific α-amylase. Export of the recombinant protein into the endosperm is effected by the signal peptide of the α-amylase precursor. Endosperm specific deposition of the recombinant proteins during grain maturation is accomplished with the promoter of the barley D-hordein storage protein gene. The signal peptide of the D-hordein precursor is employed to target the recombinant proteins into the storage vacuoles, where they are protected from degradation by the programmed cell death that destroys all endosperm DNA, nuclei, membranes and cytosol during the last stages of grain maturation in the field. With the latter system 1g recombinant protein per kg of mature grain can be produced.

[iii] The high production of recombinant proteins from microbial or human origin requires codon optimization of the DNA to a guanine + cytosine content of more than 60%. Thus, the target genes used in our transgenic plants are synthesized from appropriate synthetic oligonucleotides.
[iv] The genetically stable transformants have generally decreased grain production and thousand-grain weights. As with spontaneous and induced mutations, the decreased agronomic performance can be rectified by standard recombination breeding with elite cultivars.
[v] The low nutrional value of barley for poultry is because of the absence of an intestinal enzyme for efficient de-polymerization of (1,3-1,4)-β-glucans, the major polysaccharide of the endosperm cell walls. This leads to a high viscosity in the intestine, limited nutrient uptake, decreased growth rate, and unhygienic sticky droppings adhering to the chickens and floors of the production cages. Consequently, the 7.5 billion broiler chickens produced annually in the U.S. are raised on corn-soybean diets. In a trial with 240 chickens it was shown that addition to normal barley of 6.2% transgenic malt containing a thermotolerant (1,3-1,4)-β-glucanase [4.28 $\mu g \cdot g^{-1}$ soluble protein] provides a weight gain equivalent to corn diets. The number of birds with adhering sticky droppings is drastically reduced. Intestines and excrements of chickens fed the barley control diet contained large amounts of soluble (1,3-1,4)-β-glucans, which was reduced by 75% and 50%, respectively, by adding transgenic malt to the diet. The amount of active recombinant enzyme in the small intestine corresponded to that present in the feed, whereas an 11-fold concentration of the enzyme was observed in the ceca and a 7.5 fold concentration occurred in the excrement. Glycosylation of the β-glucanase isolated from the ceca testified to its origin from the transgenic barley and not from resident microbes. Analysis of the data from this trial demonstrates the possibility of introducing individual recombinant enzymes into various parts of the gastrointestinal tract of chickens with transgenic malt and thereby the possibility of evaluating their effect on the metabolism of a given ingredient targeted by the enzyme. In a second chicken trial with 160 broiler chicks the formation of sticky droppings was entirely avoided by increasing the amount of transgenic malt addition to 15%. The transgenic lines have been propagated and a ton quantity has been malted in a special, isolated plant constructed for genetically engineered barley at Germany's largest malting company and returned to Pullman.
In two further trials we also included a diet in which 3.9% and 0.8% mature, transgenic barley grain containing a high amount of the protein-engineered (1,3-1,4)-β-glucanase was added to the normal barley. This small addition likewise made the barley diet a high energy feed competing positively with the corn diet. In analyzing the transgenic grain we discovered that it only contained very small amounts of (1,3-1,4)-β-glucan in the endosperm cell walls. The grain germinates normal and accumulates starch and protein including the recombinant enzyme. This opens the way to breed barley that no longer contains the anti-nutritional (1,3-1,4)-β-glucans.
[vi] We have recently developed a technology, which allows the determination of the transgene insertion site in the barley genome at the nucleotide sequence level. From the identified barley sequences next to the transgene insertion site oligonucleotide primers are designed and used by PCR (polymerase chain reaction) to distinguish uniquely any transformant from any other transformant as well as any cultivar. It is thus possible to satisfy requests by regulatory authorities for unique identification of a cereal cultivar to be marketed. The technique also allows detection of trace contaminants in grain samples.

Eonomic perspectives.
Advantages in using the transgenic malt or mature grain containing the thermostable (1,3-1,4)-β-glucanase for chicken feed are several. The required malt or mature grain corresponding in

amount to the feed ingredients such as fish meal, beef tallow or dicalcium phosphate can be added to normal barley in areas that have to import grain corn as a major basis of feed. It provides an alternative to the use of corn grain, which is more extensively used and needed as food for humans than barley. Corn grain is also at times 30-50% more expensive. Only 10% of the barley harvest in the U.S. is used as malt for beer and less than 1% for production of ingredients in human food (Washington Agricultural Statistics 1997-1998). The state of Washington produces annually 40 million broilers with imported corn grain. If barley is to be used for raising this number of broiler chickens it would require 3,400 t of presently obtainable transgenic malt or much less mature transgenic grain and 280,000 t of normal barley, i.e. ~ 1/3 of the barley harvest of the state. Barley is needed in Washington agriculture for crop rotation.

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WSU EXTENSION UNIFORM CEREAL VARIETY TESTING PROGRAM – 2001

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The goal of the WSU Extension Uniform Cereal Variety Testing Program is to provide comprehensive, objective and readily available information on the performance of public and private cereal varieties to Washington growers. The WSU Winter Wheat, Spring Wheat, Spring Barley and USDA-ARS Winter Club breeding programs work in cooperation with the WSU Extension Uniform Cereal Variety Testing Program in design, establishment, harvest, and data analysis from variety testing nurseries. Varieties submitted by private companies are on a fee-for-entry basis. In order to obtain a uniform data set of comparisons all entries are grown at all locations.

The diverse growing condition characteristic of eastern Washington necessitates using a large number of testing sites. There were 20-winter wheat, 16-spring wheat and 15-spring barley nurseries grown in 2001. Data for all winter and spring trials are included in the following tables. Statistical data from the Washington Agricultural Statistic Service, Olympia, WA, is also included to show acreages of specific varieties raised in Washington State.

Growing conditions for winter wheat during crop year 2001 were heavily influenced by below normal precipitation throughout the state with areas in the northern wheat producing regions having extended snow cover for over 140 days. Spring crops were even more adversely impacted with below normal precipitation during the growing season. In addition, spring crops were subjected to early-season cold soil temperatures and severe frost injury in some areas that caused extensive damage. Both the Bickleton and Ritzville spring wheat and spring barley nurseries were not harvested due to severe drought stress. Average yields for all winter wheat varieties in the trials combined across all locations was nearly 18% lower (20.4 bu/ac) than the previous year (2000). Average nursery yields for spring wheat and spring barley were 19.3% and 20.6% lower in 2001 than the previous year, respectively.

A complete listing for each testing location is available on a Web site maintained by the WSU Extension Variety Testing Program: http://variety.wsu.edu Included in the Web site is 3-5 year average yields for each variety at each testing location.

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2001 WSU Winter Wheat Variety Trial Summary (Soft White) - YIELD

VARIETY NAME	LIND DRY	RITZVILLE	ANATONE	ST. ANDREWS	BICKLETON	ALMIRA	LAMONT	WALLA WALLA	FAIRFIELD	DUSTY	DAYTON	CRESTON	REARDAN	ST. JOHN	FARMINGTON
Soft White Common															
A96105	34.4	44.1	46.2	48.0	54.4	84.1	79.3	83.1	88.0	95.1	92.8	108.4	113.5	105.6	112.2
ALBION	30.2	47.9	45.0	52.8	54.4	73.9	84.4	88.2	93.2	95.7	100.5	104.6	108.7	103.7	133.6
B6W93-477	28.1	47.3	53.0	53.8	50.5	83.9	84.4	102.9	101.9	99.4	107.9	103.3	105.4	122.6	136.1
BASIN	19.6	42.8	51.8	41.9	44.6	76.9	78.2	79.7	93.0	93.7	99.4	95.0	96.9	99.4	106.8
BEAMER	28.8	45.7	50.6	38.5	48.8	77.0	86.5	89.6	94.6	99.7	103.1	101.3	106.8	113.9	120.8
BRUNDAGE 96	29.8	46.1	56.6	54.8	46.6	81.8	86.4	94.7	95.4	100.2	112.4	101.4	109.2	109.3	123.4
CASHUP	24.7	44.3	44.4	51.2	44.6	80.8	78.1	88.4	99.0	94.5	100.6	97.9	101.4	125.8	128.9
ELTAN	28.9	50.5	46.5	58.1	50.3	79.7	88.1	94.6	98.7	103.5	91.8	111.4	113.3	112.9	111.3
ELTAN-MADSEN 50-50	28.4	47.1	51.6	55.1	52.2	75.4	86.5	88.4	94.7	97.0	96.7	105.2	114.8	110.0	131.2
FINCH	27.8	50.1	52.2	57.8	58.3	82.7	91.0	103.2	99.7	100.5	102.9	105.8	112.1	108.0	124.8
GT 123-64	30.7	43.4	47.4	46.1	52.6	71.1	84.2	85.9	94.2	96.2	97.8	101.7	111.3	115.3	125.5
HILL 81	28.6	43.2	51.7	44.3	50.7	83.3	77.0	94.2	96.3	92.2	104.2	101.4	103.8	116.7	108.9
HUBBARD	31.0	46.7	42.9	46.3	55.4	71.0	81.5	101.9	101.1	97.4	94.0	102.8	113.6	112.8	122.2
ID17113A	26.7	45.9	53.2	43.5	50.7	73.1	81.2	86.6	96.6	93.3	105.5	101.1	102.3	110.4	116.2
ID52814A	26.9	44.9	52.8	60.7	54.3	78.4	80.2	93.3	98.7	99.6	90.4	107.4	117.4	105.3	119.9
LAMBERT	33.3	44.7	52.3	43.8	53.9	75.1	86.5	97.2	101.3	108.2	98.5	99.1	107.6	125.8	110.2
LAMBERT-MADSEN 50-50	27.5	47.0	43.3	43.3	50.0	83.4	87.9	101.8	103.1	103.4	101.1	100.7	106.7	124.4	127.7
LEWJAIN	26.0	45.1	50.7	53.2	52.4	69.1	80.7	87.9	92.0	92.6	95.7	106.6	108.3	103.6	111.5
MADSEN	23.4	46.3	50.8	42.6	45.7	77.7	83.2	84.4	97.5	92.3	104.2	103.6	101.3	108.1	123.1
MADSEN-ROD 50-50	28.5	46.7	49.5	45.3	51.4	69.0	90.5	102.4	99.7	103.2	104.4	104.5	112.5	122.1	129.8
MJ-4	30.0	46.9	53.1	54.7	49.3	80.4	88.2	86.4	94.6	95.6	103.3	107.1	111.9	120.4	125.7
MJ-9	31.2	44.7	43.9	52.4	49.0	77.6	90.4	89.8	98.4	102.4	93.6	105.5	101.6	124.0	139.8
OR939526	35.5	46.2	49.0	45.7	51.2	77.0	91.0	99.2	102.8	101.4	108.2	112.1	111.7	114.6	130.8
ROD	25.2	47.7	49.9	57.7	51.8	79.8	94.3	96.1	102.9	110.2	109.2	102.2	108.3	118.2	125.3
STEPHENS	29.4	42.3	46.0	37.6	50.3	77.4	82.3	108.4	91.2	100.0	108.8	97.8	103.4	109.6	122.3
WEATHERFORD	34.0	45.5	48.7	40.1	47.0	84.2	85.6	90.2	90.9	90.9	104.5	100.5	101.2	108.9	126.7
WESTBRED 470	29.7	42.5	46.7	32.9	45.4	63.8	87.2	98.5	89.9	104.2	113.5	92.6	88.7	115.4	119.7
Soft White Club															
BRUEHL	17.7	54.9	40.6	66.6	49.4	77.4	86.3	97.6	97.3	97.0	110.8	110.1	114.4	119.6	133.2
CHUKAR	26.8	46.1	49.2	47.2	49.8	81.4	92.7	96.3	102.9	110.4	108.7	110.6	107.1	121.9	120.7
CODA	23.8	45.3	46.7	51.2	54.4	93.4	85.6	95.5	101.0	100.3	105.3	100.9	97.0	115.9	121.6
EDWIN	31.8	44.7	49.0	55.4	55.0	76.8	82.6	84.6	91.8	88.6	89.9	94.6	95.1	111.5	92.9
HILLER	28.7	47.0	47.4	54.5	46.5	90.2	92.4	99.6	102.1	112.6	114.9	104.8	109.0	126.6	129.6
RELY	30.5	49.3	37.4	55.6	47.5	86.1	91.4	103.6	93.2	108.2	101.7	107.3	103.9	116.2	126.9
ROHDE	25.0	39.6	50.8	41.4	44.3	73.4	78.9	87.3	101.4	92.0	92.6	100.5	94.3	101.2	126.5
TEMPLE	20.8	41.7	49.3	48.6	36.5	75.8	72.9	102.1	95.6	83.3	105.5	104.2	96.2	113.5	117.9
WA7871	16.3	44.8	38.5	46.6	50.6	84.5	83.4	97.4	97.7	92.8	106.2	107.7	107.9	111.1	121.1
Hard Red Common															
ESTICA	39.0	44.1	44.9	38.7	58.3	84.5	89.7	103.3	97.9	102.9	100.0	103.3	108.0	116.3	121.7
PILLAR	23.6	39.6	40.9	.	40.7	56.5	74.2	82.8	84.9	91.2	94.7	71.3	80.5	108.8	103.1
RESIDENCE	42.2	50.4	50.1	51.4	65.8	93.2	97.8	110.6	109.8	111.4	110.1	109.8	114.8	123.8	132.2
SEMPER	40.6	52.9	49.5	44.1	67.4	87.1	99.3	99.5	102.9	116.9	108.3	105.1	118.6	132.6	128.6
NURSERY MEAN	28.6	45.9	48.1	48.8	50.8	78.7	85.6	94.4	97.2	99.3	102.3	102.8	106.0	114.6	122.3
CV %	15.9	8.4	14.1	19.1	8.5	15.7	4.8	8.8	5.3	6.0	4.0	7.3	7.1	7.2	7.9
LSD @ .10	5.3	4.5	8.4	10.9	5.0	14.5	4.8	9.7	6.0	7.0	4.8	8.8	8.8	9.7	11.3

2001 WSU Winter Wheat Variety Trial Summary (Soft White) – TEST WEIGHT

VARIETY NAME	LIND DRY	RITZVILLE	ANATONE	ST. ANDREWS	BICKLETON	ALMIRA	LAMONT	WALLA WALLA	FAIRFIELD	DUSTY	DAYTON	CRESTON	REARDAN	ST. JOHN	FARMINGTON
Soft White Common															
A96105	60.5	57.6	59.6	58.2	60.7	60.1	58.5	53.9	56.1	56.9	58.4	59.0	59.7	58.9	55.8
ALBION	61.3	58.6	58.3	58.6	59.4	60.0	58.5	56.6	59.0	58.6	58.2	60.4	61.6	57.9	61.6
B6W93-477	62.4	60.7	60.2	60.4	60.8	61.5	60.6	58.6	60.4	60.1	60.1	60.7	61.8	61.5	61.9
BASIN	61.2	60.4	59.6	60.2	60.8	60.4	59.5	57.0	60.8	59.5	60.4	61.9	62.7	60.1	60.3
BEAMER	62.4	60.8	61.1	59.7	61.6	61.8	61.0	58.8	60.9	60.4	60.4	61.5	62.2	61.3	60.9
BRUNDAGE 96	62.4	60.7	60.8	60.1	60.1	61.6	59.9	58.0	60.6	59.6	60.9	60.7	61.5	60.7	60.5
CASHUP	63.0	61.5	60.9	60.6	61.5	61.7	61.1	58.8	61.1	60.6	59.8	61.4	62.1	61.0	62.3
ELTAN	61.4	61.3	62.2	60.7	61.3	61.2	60.3	58.5	61.5	59.2	59.9	61.1	61.3	61.3	59.8
ELTAN-MADSEN 50-50	61.6	61.4	61.4	60.9	61.1	61.3	60.3	57.5	59.7	59.2	60.1	60.9	61.4	60.8	61.5
FINCH	62.6	60.7	61.6	60.6	61.2	62.1	61.2	59.2	62.0	60.2	61.6	62.0	62.2	61.8	60.7
GT 123-64	61.6	58.6	58.3	58.7	59.5	60.1	58.9	56.6	59.2	58.5	57.6	60.5	61.4	58.7	60.7
HILL 81	62.8	61.5	62.0	60.4	61.2	61.4	60.6	59.6	62.1	60.4	61.2	61.0	61.5	61.7	60.7
HUBBARD	62.9	61.0	61.4	60.9	61.3	62.1	60.8	59.4	62.3	60.6	60.9	61.7	62.4	60.7	61.4
ID17113A	61.7	60.5	61.0	60.0	60.9	61.3	59.9	57.3	60.5	59.5	60.1	60.8	61.2	60.3	59.9
ID52814A	62.1	60.2	61.2	61.7	61.6	62.1	60.8	58.4	61.9	60.2	59.7	61.8	62.6	61.3	61.5
LAMBERT	62.4	59.8	60.4	60.3	60.2	61.1	60.4	59.0	61.2	59.8	59.7	60.7	62.0	60.7	59.6
LAMBERT-MADSEN 50-50	62.3	61.0	60.5	59.8	60.5	61.0	60.1	58.1	61.7	59.6	60.1	60.6	61.6	61.1	61.0
LEWJAIN	63.0	60.5	62.3	61.7	62.1	62.4	60.9	58.7	60.9	59.0	60.4	61.9	62.5	61.7	59.9
MADSEN	61.9	61.1	60.8	59.6	61.3	61.1	59.7	57.8	60.4	59.5	60.5	60.5	61.1	60.7	60.1
MADSEN-ROD 50-50	61.6	59.8	59.6	59.3	60.3	60.6	59.2	56.5	59.7	58.5	59.1	60.3	61.0	60.0	60.2
MJ-4	61.2	57.9	59.4	58.0	59.6	59.6	58.6	53.4	57.8	58.1	56.9	59.2	60.2	59.5	58.8
MJ-9	61.2	57.7	58.0	58.7	58.8	59.8	57.6	55.1	58.1	57.9	55.8	59.9	61.3	58.8	60.8
OR939526	61.5	59.2	59.2	58.2	59.6	60.2	59.5	57.3	59.9	59.2	58.8	60.4	61.1	60.0	60.4
ROD	61.0	58.2	58.8	59.4	59.5	60.4	58.2	56.8	59.5	57.6	58.1	60.2	61.0	59.1	58.8
STEPHENS	61.9	59.8	59.3	59.6	59.8	60.1	60.2	57.6	59.2	59.9	60.9	60.1	60.9	60.3	60.2
WEATHERFORD	62.2	60.7	60.7	59.3	60.9	61.2	60.2	57.7	60.9	59.2	60.3	61.1	61.4	60.4	61.1
WESTBRED 470	63.5	63.9	61.4	61.4	63.4	62.2	63.0	61.9	62.2	62.1	63.8	63.5	63.4	63.2	63.6
Soft White Club															
BRUEHL	60.8	59.8	60.4	58.7	60.0	60.5	59.2	56.7	59.2	58.3	57.9	59.3	59.3	59.2	59.4
CHUKAR	61.8	55.9	60.0	58.9	58.3	60.6	58.2	56.6	60.6	57.3	58.1	59.8	60.0	60.0	59.7
CODA	62.4	61.1	60.3	61.4	60.5	62.0	61.0	57.8	63.2	60.5	61.2	62.7	62.4	61.9	63.1
EDWIN	63.4	60.4	61.3	60.6	59.7	61.9	61.5	59.5	62.7	60.1	61.3	62.4	61.6	62.8	62.0
HILLER	62.2	58.4	59.9	57.7	57.7	60.2	58.7	55.4	59.7	57.1	57.8	58.3	58.8	58.8	60.0
RELY	62.7	59.0	60.6	60.2	59.4	61.6	59.8	58.7	62.0	58.7	59.3	60.6	60.7	61.2	62.1
ROHDE	63.1	61.9	62.2	61.7	61.5	62.1	61.8	59.6	63.4	59.9	61.5	62.6	63.0	62.2	63.2
TEMPLE	63.2	60.1	60.5	60.2	60.1	60.8	60.9	60.1	60.9	59.9	60.2	61.4	61.3	62.0	61.5
WA7871	60.2	56.4	59.7	57.6	58.1	59.9	58.9	55.2	59.7	57.4	57.3	58.6	59.2	58.5	59.6
Hard Red Common															
ESTICA	60.1	55.2	56.2	56.3	56.5	58.1	56.8	54.8	59.1	56.4	56.3	58.8	59.4	58.3	58.4
PILLAR	62.6	61.4	59.6	.	61.8	60.2	60.9	59.4	62.3	60.4	61.6	61.9	61.4	62.2	61.7
RESIDENCE	62.6	58.8	58.1	59.2	59.6	62.1	58.8	58.8	61.5	60.0	60.0	61.0	61.9	61.2	62.3
SEMPER	61.7	58.9	56.7	58.5	59.4	60.9	58.5	58.1	61.1	60.0	59.1	60.2	61.5	60.8	61.6
NURSERY MEAN	62.0	59.8	60.1	59.7	60.3	61.0	59.9	57.7	60.6	59.3	59.6	60.8	61.4	60.6	60.7
CV %	0.7	0.9	1.0	1.1	0.8	0.9	0.5	1.4	1.3	0.8	1.0	0.6	0.8	1.1	1.5
LSD @ .10	0.5	0.7	0.7	0.8	0.6	0.7	0.4	1.0	0.9	0.6	0.7	0.4	0.6	0.8	1.1

2001 WSU Winter Wheat Variety Trial Summary (Soft White) - % PROTEIN

VARIETY NAME	LIND DRY	RITZVILLE	ANATONE	ST. ANDREWS	BICKLETON	ALMIRA	LAMONT	WALLA WALLA	FAIRFIELD	DUSTY	DAYTON	CRESTON	REARDAN	ST. JOHN	FARMINGTON
Soft White Common															
A96105	12.5	11.5	13.6	10.8	9.8	11.5	9.5	13.9	12.9	10.6	10.2	8.5	9.1	10.6	11.9
ALBION	12.6	11.3	12.8	11.8	9.4	11.9	9.2	12.5	12.3	10.2	9.4	8.7	9.9	10.2	10.5
B6W93-477	13.1	11.7	13.5	10.6	9.8	11.7	9.1	12.5	11.6	9.8	9.7	8.5	9.6	9.3	11.1
BASIN	12.7	10.9	12.7	10.8	9.4	11.8	9.1	11.9	11.3	9.6	8.8	8.6	9.5	10.1	11.2
BEAMER	12.5	11.4	13.1	11.5	9.8	11.2	9.2	12.5	11.7	10.0	9.9	8.8	9.6	10.2	11.7
BRUNDAGE 96	12.0	11.2	13.3	10.9	9.2	11.3	8.7	12.3	11.5	10.0	8.9	9.0	9.6	9.7	11.3
CASHUP	12.6	11.0	13.6	10.6	9.9	11.7	9.3	12.6	11.7	9.4	9.4	8.9	9.8	9.8	11.4
ELTAN	12.6	10.6	13.1	10.9	9.5	11.4	8.3	13.1	11.5	9.9	9.8	8.1	8.4	9.5	11.0
ELTAN-MADSEN 50-50	13.1	10.5	13.4	10.8	9.2	11.8	8.9	13.3	12.2	10.2	9.9	8.6	9.6	10.3	10.8
FINCH	12.4	10.8	13.2	10.4	8.9	11.4	8.6	12.7	11.1	9.6	8.9	8.2	8.2	10.2	11.5
GT 123-64	12.3	11.4	13.0	11.7	9.4	11.5	9.5	12.4	12.0	10.3	9.9	8.7	10.0	9.7	10.6
HILL 81	12.8	11.4	12.9	11.6	9.5	12.0	8.8	12.7	11.7	9.8	9.9	9.0	9.4	9.7	12.0
HUBBARD	13.3	11.3	14.3	11.7	9.6	12.0	9.2	12.6	11.5	10.5	9.2	9.0	10.0	10.0	11.5
ID17113A	13.2	11.6	12.6	11.9	9.6	11.9	9.1	12.9	12.0	10.3	9.9	8.9	9.8	10.1	11.8
ID52814A	13.0	11.5	12.8	10.1	9.2	10.7	9.2	12.4	11.5	10.0	9.7	8.3	9.1	9.5	10.9
LAMBERT	12.1	11.6	12.4	11.6	9.6	11.2	9.3	12.0	11.5	10.0	9.8	8.9	10.1	9.7	11.9
LAMBERT-MADSEN 50-50	13.1	11.3	14.2	11.2	9.5	11.8	9.0	12.5	11.7	9.8	9.1	8.9	9.9	9.7	11.4
LEWJAIN	13.1	11.9	13.4	10.5	9.5	11.8	9.1	13.1	11.9	10.2	10.1	8.5	9.1	9.7	11.7
MADSEN	13.7	11.4	13.6	11.6	10.1	11.6	9.1	13.1	12.2	10.5	10.1	9.0	9.1	10.3	11.7
MADSEN-ROD 50-50	12.8	11.2	13.6	10.7	9.4	11.8	9.0	12.5	11.9	9.9	9.3	8.7	10.2	9.6	11.2
MJ-4	12.6	11.2	13.1	11.2	9.6	11.3	8.6	13.2	11.8	10.0	10.1	8.3	9.7	9.5	11.6
MJ-9	12.2	11.4	13.5	11.1	9.4	12.2	8.2	12.6	11.7	9.2	9.9	8.5	9.5	9.3	10.8
OR939526	12.1	11.4	12.6	11.2	9.5	11.1	9.0	12.4	11.2	9.8	9.7	8.7	9.4	9.6	10.6
ROD	12.4	11.3	12.7	10.4	9.1	11.3	8.1	12.1	11.4	9.7	9.2	8.3	8.6	9.5	11.2
STEPHENS	12.5	11.9	13.8	11.6	10.1	12.0	9.3	12.4	12.2	10.3	9.3	9.2	9.7	10.8	11.6
WEATHERFORD	12.5	11.8	13.7	11.9	10.2	12.1	9.2	13.0	12.1	10.2	9.3	9.3	9.6	10.2	11.5
WESTBRED 470	13.0	12.2	14.3	12.4	11.0	13.9	9.1	12.5	12.0	9.9	10.0	10.0	11.2	9.7	11.7
Soft White Club															
BRUEHL	13.7	10.6	14.4	10.4	9.6	11.3	8.6	12.9	12.1	10.3	9.7	8.0	9.1	9.0	11.0
CHUKAR	12.4	10.9	13.1	10.5	8.6	10.6	8.0	12.5	11.8	8.9	8.3	8.0	8.2	8.9	11.3
CODA	13.7	11.0	14.6	11.5	8.7	12.1	8.6	13.5	12.1	9.8	9.1	9.6	9.8	9.8	11.6
EDWIN	12.2	10.7	13.6	10.1	8.3	12.0	8.8	13.5	12.4	9.7	10.0	9.1	10.5	10.2	12.5
HILLER	11.7	10.6	13.2	11.0	8.5	11.1	8.8	11.8	11.6	9.5	8.3	8.1	9.3	9.0	11.1
RELY	12.2	10.7	14.2	10.5	8.9	11.4	8.0	12.1	11.6	8.9	9.2	8.3	9.1	9.1	11.0
ROHDE	12.7	11.2	13.6	12.1	9.1	12.4	9.4	12.7	12.4	10.6	9.3	9.6	9.9	10.4	11.7
TEMPLE	13.2	11.4	13.3	11.4	9.5	11.4	9.5	12.0	11.6	10.8	9.1	8.6	9.3	9.6	11.4
WA7871	13.5	10.8	13.7	9.7	9.2	10.6	8.8	12.2	11.2	10.2	8.7	7.5	8.4	9.5	11.0
Hard Red Common															
ESTICA	12.1	10.6	14.1	11.3	9.8	12.0	9.2	12.7	11.8	10.6	9.3	9.3	9.7	10.4	11.4
PILLAR	15.5	12.8	15.3	.	12.1	14.7	10.2	13.7	14.2	11.5	11.3	11.4	12.7	11.3	13.4
RESIDENCE	12.3	10.8	14.0	10.7	9.2	11.5	8.6	12.6	11.7	9.7	9.4	8.9	9.4	9.7	11.2
SEMPER	12.2	10.9	13.5	11.2	9.6	11.5	8.4	12.4	11.3	9.8	10.0	8.9	9.8	9.5	11.2
NURSERY MEAN	12.8	11.3	13.5	11.1	9.5	11.7	9.0	12.7	11.9	10.0	9.5	8.8	9.6	9.8	11.4
CV %	3.8	3.8	4.5	6.8	5.3	4.1	5.2	2.4	4.1	6.0	6.9	4.8	6.7	5.0	4.0
LSD @ .10	0.6	0.5	0.7	0.9	0.6	0.6	0.6	0.4	0.6	0.7	0.8	0.5	0.8	0.6	0.5

2001 WSU Winter Wheat Variety Trial Summary (Hard Red) - YIELD

VARIETY NAME	HORSE HEAVEN	LIND	CONNELL	BICKLETON	ST. ANDREWS	PULLMAN	VARIETY MEAN
Hard White Common							
ID550	12.8	29.7	43.6	47.9	52.8	98.9	44.6
GEN MILLS 1	13.3	24.0	35.9	45.1	64.8	80.5	42.2
GEN MILLS 2	11.4	24.3	34.5	43.4	47.9	88.7	38.6
Hard Red Common							
5J950368	13.4	29.8	42.1	45.2	48.8	89.4	42.2
5J950374	7.7	23.6	42.0	48.9	53.9	84.8	40.9
BOUNDARY	11.6	27.4	44.2	52.1	63.0	84.7	44.7
BUCHANAN	13.0	31.0	49.1	46.5	64.9	69.5	44.1
COLUMBIA - 1	14.0	22.5	35.4	41.6	35.4	94.8	37.3
ESTICA	11.1	32.7	47.4	56.3	39.1	98.9	45.4
FINLEY	13.4	27.2	47.8	55.6	50.5	76.5	44.7
HATTON	12.7	24.0	46.9	50.0	52.1	72.7	41.2
ID517	13.2	26.7	38.5	48.8	53.7	86.5	42.2
N9502203	11.8	25.4	32.2	50.8	44.4	67.5	37.8
N9502601	12.8	30.4	44.5	49.8	50.3	64.0	40.5
N9502606	14.3	27.7	41.7	46.1	56.5	65.7	40.7
N9505403	14.8	25.0	41.7	47.6	59.4	71.2	40.9
N9988120	12.7	34.5	46.5	58.4	68.0	83.8	49.4
N9988121	12.9	29.3	43.0	56.1	48.4	83.6	43.9
QHYB 542	15.1	33.8	41.5	54.7	58.0	85.5	46.3
RESIDENCE	11.6	35.6	54.6	60.5	48.9	111.9	51.9
SEMPER	13.9	33.7	49.3	56.7	47.1	111.3	50.0
SYMPHONY	13.7	23.2	41.2	46.9	61.8	93.2	44.5
WANSER	13.9	24.3	33.7	42.6	41.1	70.3	36.4
WESTON	14.1	29.2	41.6	43.9	52.6	92.8	45.0
Soft White Common							
ELTAN	11.3	27.9	54.9	48.4	75.1	90.1	48.2
NURSERY MEAN	12.8	28.1	43.0	49.8	53.5	84.7	43.3
CV %	14.8	17.9	11.4	8.9	18.6	10.3	14.4
LSD @ .10	2.2	5.9	5.8	5.2	11.7	10.3	2.8

2001 WSU Winter Wheat Variety Trial Summary (Hard Red) – TEST WEIGHT

VARIETY NAME	HORSE HEAVEN	LIND	CONNELL	BICKLETON	ST. ANDREWS	PULLMAN	VARIETY MEAN
Hard White Common							
ID550	60.5	63.3	62.4	61.3	61.6	62.1	62.2
GEN MILLS 1	60.7	64.2	63.4	63.0	63.0	63.7	63.4
GEN MILLS 2	61.3	64.5	63.5	63.6	63.1	63.9	63.7
Hard Red Common							
5J950368	60.2	62.9	62.9	62.6	61.8	62.6	62.5
5J950374	57.7	62.5	61.5	61.8	61.1	61.9	61.5
BOUNDARY	58.9	62.2	60.6	60.4	60.9	61.7	61.0
BUCHANAN	60.8	63.0	62.9	60.0	60.5	61.6	61.7
COLUMBIA - 1	59.1	62.8	62.1	62.0	61.4	61.4	61.9
ESTICA	56.3	59.3	57.7	56.2	55.9	58.4	57.5
FINLEY	61.3	63.2	63.7	62.5	62.1	63.3	62.9
HATTON	62.8	63.3	64.2	63.5	62.0	63.7	63.4
ID517	58.6	62.3	61.1	61.5	60.7	60.8	61.1
N9502203	61.3	63.9	62.9	62.1	62.6	63.5	62.9
N9502601	61.5	63.3	63.5	62.3	61.8	62.9	62.8
N9502606	61.2	63.5	63.1	61.8	62.0	62.6	62.6
N9505403	61.3	62.8	63.2	61.8	61.9	62.8	62.5
N9988120	59.8	62.3	62.1	61.4	61.5	63.0	62.0
N9988121	59.9	62.4	62.5	61.7	61.5	63.1	62.0
QHYB 542	59.2	63.5	62.8	62.1	61.9	62.7	62.4
RESIDENCE	56.2	62.2	59.4	59.7	58.5	61.8	60.0
SEMPER	55.7	61.6	59.8	59.5	58.7	61.0	59.7
SYMPHONY	57.8	62.0	61.0	59.9	60.2	60.7	60.7
WANSER	60.4	63.8	62.9	62.4	61.8	63.3	62.7
WESTON	61.0	63.8	63.0	63.0	62.6	63.2	63.0
Soft White Common							
ELTAN	59.5	61.3	62.1	60.6	60.4	62.3	61.5
NURSERY MEAN	59.7	62.8	62.2	61.5	61.2	62.3	61.9
CV %	*	0.7	1.0	1.1	1.0	0.9	0.9
LSD @ .10	*	0.5	0.7	0.8	0.7	0.7	0.3

2001 WSU Winter Wheat Variety Trial Summary (Hard Red) - % PROTEIN

VARIETY NAME	HORSE HEAVEN	LIND	CONNELL	BICKLETON	ST. ANDREWS	PULLMAN	VARIETY MEAN
Hard White Common							
ID550	13.7	13.1	12.2	9.3	9.9	11.1	11.6
GEN MILLS 1	13.9	13.4	12.4	9.5	11.4	11.0	11.9
GEN MILLS 2	14.7	14.1	13.3	10.9	10.2	10.5	12.4
Hard Red Common							
5J950368	14.3	13.1	13.3	10.2	11.2	11.5	12.3
5J950374	15.7	14.7	13.4	10.6	11.0	11.9	12.8
BOUNDARY	15.0	13.6	13.4	9.7	11.1	12.2	12.4
BUCHANAN	14.4	13.1	12.8	9.0	10.1	11.7	11.9
COLUMBIA - 1	15.5	14.6	13.2	11.3	11.9	12.3	13.2
ESTICA	15.6	12.2	12.8	10.0	12.0	12.2	12.3
FINLEY	14.8	13.6	13.4	10.1	10.8	12.4	12.5
HATTON	14.3	14.0	13.1	9.5	10.9	12.3	12.5
ID517	15.2	14.1	14.2	10.3	12.0	12.1	13.0
N9502203	14.8	13.3	13.3	9.3	10.6	11.9	12.2
N9502601	15.1	13.9	12.7	10.6	11.6	12.8	12.8
N9502606	14.5	13.3	12.7	10.2	11.2	12.3	12.3
N9505403	14.6	13.8	12.5	9.6	10.7	12.5	12.3
N9988120	15.8	13.7	13.5	9.5	10.7	12.2	12.5
N9988121	15.5	13.2	13.0	9.5	10.6	12.4	12.3
QHYB 542	14.8	13.5	13.5	9.7	11.9	12.3	12.6
RESIDENCE	16.0	12.6	12.4	9.6	10.9	11.7	12.0
SEMPER	15.1	12.6	12.5	10.0	10.9	11.7	12.1
SYMPHONY	15.5	13.6	14.1	10.6	11.9	12.3	13.0
WANSER	14.6	13.8	13.2	10.5	12.2	12.5	12.8
WESTON	15.0	14.1	14.1	11.4	11.7	12.8	13.2
Soft White Common							
ELTAN	15.3	13.2	12.4	8.9	10.2	10.8	11.8
NURSERY MEAN	14.9	13.5	13.1	10.0	11.1	12.0	12.4
CV %	*	3.2	4.7	6.8	6.4	3.2	4.5
LSD @ .10	*	0.5	0.7	0.8	0.8	0.5	0.3

2001 WSU Spring Wheat Variety Trial Summary (Soft White) - YIELD

VARIETY NAME	LIND FALLOW	HORSE HEAVEN	LAMONT	WALLA WALLA	DAYTON	ST. JOHN	DUSTY	MAYVIEW	ALMIRA	FARMINGTON	REARDAN	FAIRFIELD	PULLMAN	ROYAL SLOPE	VARIETY MEAN
Soft White Common															
ALPOWA	20.4	20.3	30.0	33.9	40.3	48.3	61.6	53.0	64.1	74.2	80.0	84.3	86.3	131.8	59.2
BZ698-31	21.1	21.0	29.1	39.9	45.2	45.7	48.5	63.3	65.2	73.2	78.1	79.0	89.5	111.9	57.9
CHALLIS	20.2	21.1	22.3	30.6	42.3	45.5	55.5	60.7	68.6	70.9	79.9	74.9	85.6	115.2	56.7
EDWALL	19.0	19.2	23.7	33.5	42.8	51.5	45.6	47.6	63.7	71.6	72.2	75.6	84.2	105.3	54.0
FIELDER	17.6	20.6	23.2	28.2	38.8	54.7	47.2	60.4	59.4	72.1	71.2	74.9	78.3	108.9	54.0
ID526	19.7	21.3	30.2	33.0	44.3	41.5	53.9	56.4	53.6	77.2	76.1	82.1	96.9	115.8	57.3
JUBILEE	17.3	21.1	28.2	33.2	40.7	44.0	54.6	59.0	57.1	66.7	72.1	75.1	85.2	110.2	54.6
ML037,(C6-2)	.	.	.	.	.	.	.	.	.	.	.	.	.	125.7	125.7
PENAWAWA	19.1	19.9	22.0	26.2	37.9	46.6	45.4	57.9	55.4	62.8	72.2	71.3	80.1	108.1	51.8
WA7877	23.0	21.4	27.3	29.1	43.0	56.5	62.6	56.3	56.6	71.3	64.2	79.2	88.6	138.4	58.4
WA7883	16.8	22.5	22.8	33.0	42.8	50.1	52.1	55.6	53.4	72.7	74.3	82.3	94.6	114.8	56.3
WA7884	22.8	20.6	32.0	34.2	39.0	51.6	60.7	55.5	59.5	70.6	66.0	82.3	94.1	135.3	58.9
WA7886	20.9	21.4	23.0	31.2	39.8	43.7	41.4	47.4	56.7	71.9	73.0	77.0	89.4	116.9	53.8
WA7887	21.0	21.5	35.6	36.4	43.7	56.8	45.3	61.8	61.9	68.5	76.9	77.8	94.5	119.8	58.7
WA7890	23.8	21.3	28.6	28.1	47.5	44.5	62.7	62.7	63.4	69.9	85.4	82.9	93.3	123.7	59.8
WA7905	24.9	22.2	28.3	34.0	44.8	47.6	53.3	43.2	59.2	74.7	88.6	87.4	94.8	127.7	59.4
WAWAWAI	22.5	20.3	26.0	31.0	38.3	46.4	57.5	57.4	59.3	71.9	72.3	79.3	91.2	119.3	56.6
ZAK	21.4	21.0	28.0	34.7	38.9	44.2	52.8	53.8	56.7	65.0	74.8	78.0	90.3	133.2	56.6
Soft White Club															
CALORWA	18.3	19.5	19.8	34.6	39.4	46.7	38.6	48.5	54.4	66.8	72.7	76.0	82.7	96.0	51.0
WA7902	21.7	21.7	23.7	37.6	43.7	52.2	50.7	57.7	57.3	68.7	83.3	89.2	91.1	114.1	58.1
WA7904	18.5	16.2	33.2	36.6	39.6	52.3	56.9	52.9	52.4	70.0	73.7	78.5	81.9	106.3	54.9
NURSERY MEAN	20.5	20.7	26.8	33.0	41.7	48.5	52.4	55.6	58.9	70.5	75.4	79.4	88.6	118.0	56.6
CV %	8.1	7.6	16.8	16.2	10.6	15.3	19.5	10.0	9.0	8.2	10.0	4.2	4.2	7.6	10.4
LSD @ .10	2.3	2.2	6.2	7.3	6.0	10.2	14.0	7.6	7.3	7.9	10.4	1.6	5.1	12.3	2.7

2001 WSU Spring Wheat Variety Trial Summary (Soft White) – TEST WEIGHT

VARIETY NAME	LIND FALLOW	HORSE HEAVEN	LAMONT	WALLA WALLA	DAYTON	ST. JOHN	DUSTY	MAYVIEW	ALMIRA	FARMINGTON	REARDAN	FAIRFIELD	PULLMAN	ROYAL SLOPE	VARIETY MEAN
Soft White Common															
ALPOWA	61.3	59.8	61.7	56.4	63.1	57.9	60.0	63.0	62.3	59.9	61.1	63.5	62.5	64.1	61.2
BZ698-31	60.6	60.2	60.5	57.0	61.5	56.1	58.6	62.2	61.2	59.6	60.5	62.9	61.6	63.3	60.4
CHALLIS	60.6	59.1	60.2	54.1	61.0	56.0	58.9	61.4	61.7	57.7	60.0	61.7	60.4	63.0	59.7
EDWALL	59.8	57.4	58.6	52.3	59.8	55.8	56.2	59.4	60.2	57.7	57.3	60.3	58.0	62.2	58.2
FIELDER	60.7	60.3	60.3	54.6	61.9	58.1	58.4	62.0	61.1	59.1	59.8	62.4	59.3	63.2	60.1
ID526	61.0	60.3	60.9	56.0	61.7	56.7	58.9	62.7	61.7	59.9	59.7	61.7	61.8	63.3	60.5
JUBILEE	61.5	61.3	61.4	56.0	62.2	56.8	59.9	62.3	62.2	59.9	60.6	62.9	60.9	64.2	60.8
ML037,(C6-2)	.	.	.	.	.	.	.	.	.	.	.	.	.	62.6	62.6
PENAWAWA	60.5	57.4	60.0	53.3	61.8	57.4	57.6	61.8	61.7	59.2	60.2	63.1	60.8	63.4	60.0
WA7877	59.3	57.0	60.3	53.7	62.0	60.0	59.5	62.1	61.8	59.2	59.6	62.1	60.6	63.1	60.2
WA7883	58.9	59.3	59.5	54.2	62.2	58.9	58.2	62.8	61.3	59.6	60.5	63.5	62.3	63.2	60.4
WA7884	60.9	57.7	60.9	55.8	62.7	58.8	60.7	62.3	61.3	59.1	60.9	62.9	62.0	63.1	60.8
WA7886	59.5	57.8	58.5	54.0	59.5	54.9	55.5	60.7	59.8	57.7	58.4	61.7	60.1	62.2	58.6
WA7887	60.1	59.4	60.1	56.0	61.7	58.5	57.6	61.8	59.8	57.9	59.6	62.0	61.0	62.7	59.9
WA7890	60.9	57.9	60.7	52.2	61.5	56.7	59.5	62.6	62.2	58.0	60.7	62.2	61.5	63.5	60.1
WA7905	60.9	58.9	60.9	56.2	61.0	56.3	58.4	61.0	62.6	58.9	61.1	62.5	62.3	63.6	60.4
WAWAWAI	60.5	59.9	60.6	55.7	62.1	58.3	58.9	62.5	61.2	60.2	61.4	63.5	61.6	64.0	60.8
ZAK	60.6	59.8	60.4	56.2	61.7	58.6	59.5	62.5	60.8	58.1	59.6	61.9	61.7	62.9	60.3
Soft White Club															
CALORWA	60.6	57.7	59.3	56.0	61.3	56.8	56.9	61.6	61.1	59.2	59.6	62.2	61.4	62.6	59.8
WA7902	61.8	59.4	61.7	58.0	61.5	59.6	60.9	62.9	62.4	60.1	60.5	62.7	63.0	63.0	61.3
WA7904	60.5	57.8	60.5	57.6	60.7	58.2	59.9	61.2	61.8	58.4	59.5	60.7	60.0	62.8	60.1
NURSERY MEAN	60.5	58.9	60.3	55.3	61.5	57.5	58.7	61.9	61.4	59.0	60.0	62.3	61.1	63.1	60.2
CV %	0.6	*	0.8	2.9	0.4	2.9	2.7	0.6	0.7	2.1	1.0	0.5	1.1	0.5	1.5
LSD @ .10	0.5	*	0.6	2.2	0.3	2.3	2.1	0.5	0.6	1.7	0.8	0.5	0.9	0.5	0.4

2001 WSU Spring Wheat Variety Trial Summary (Soft White) - % PROTEIN

VARIETY NAME	LIND FALLOW	HORSE HEAVEN	LAMONT	WALLA WALLA	DAYTON	ST. JOHN	DUSTY	MAYVIEW	ALMIRA	FARMINGTON	REARDAN	FAIRFIELD	PULLMAN	ROYAL SLOPE	VARIETY MEAN
Soft White Common															
ALPOWA	13.6	13.2	14.8	12.0	10.4	14.0	13.8	11.4	11.2	11.9	8.8	8.2	10.5	12.8	11.8
BZ698-31	14.0	13.8	14.5	12.4	10.1	14.5	14.6	11.6	12.0	11.5	9.2	9.4	11.2	12.1	12.1
CHALLIS	13.6	13.2	13.9	12.2	9.7	14.0	13.5	10.9	11.2	11.0	8.5	8.0	11.1	12.2	11.6
EDWALL	13.6	12.9	14.0	12.2	10.1	13.5	13.1	11.1	11.6	10.5	9.1	8.8	11.5	12.5	11.7
FIELDER	14.2	13.0	14.6	12.7	10.2	12.7	13.5	11.7	12.1	11.1	9.3	8.6	11.9	12.6	12.0
ID526	13.3	12.7	13.6	11.4	9.8	14.1	13.8	10.8	11.3	10.7	9.1	8.7	10.5	11.9	11.5
JUBILEE	14.1	12.8	14.7	12.1	10.5	14.1	14.2	12.3	12.5	12.1	9.6	9.1	11.6	12.5	12.3
ML037,(C6-2)	.	.	.	.	.	.	.	.	.	.	.	.	.	12.4	12.4
PENAWAWA	13.9	12.6	14.3	12.9	9.5	13.7	13.6	11.5	11.8	11.0	9.0	9.0	11.5	12.6	11.9
WA7877	14.1	13.8	14.9	13.6	10.3	11.8	14.1	12.1	11.5	10.9	9.5	9.2	11.5	11.9	12.0
WA7883	14.3	12.7	14.5	13.2	9.7	13.0	13.6	11.6	11.2	12.2	9.4	8.8	10.9	12.1	11.9
WA7884	13.4	13.0	14.1	11.3	10.1	12.2	13.5	11.8	11.2	11.1	9.1	8.5	10.5	11.9	11.5
WA7886	13.6	13.2	14.0	12.3	9.5	14.5	14.9	11.1	11.4	12.5	9.4	8.9	10.7	11.7	11.9
WA7887	13.9	12.9	13.8	12.2	9.9	11.7	14.3	12.0	11.4	12.1	9.5	9.0	10.7	12.1	11.8
WA7890	13.2	13.3	13.7	13.0	9.5	14.1	13.4	10.7	10.9	12.3	8.6	8.5	10.4	12.1	11.6
WA7905	13.0	13.2	13.6	11.7	9.2	13.7	13.4	11.2	11.1	11.8	8.3	8.5	10.4	12.1	11.4
WAWAWAI	13.9	13.1	14.5	12.1	10.1	12.4	13.9	11.9	12.0	10.8	9.3	8.9	11.1	12.7	11.9
ZAK	14.0	13.9	14.9	12.1	10.5	15.3	15.2	12.3	11.9	12.7	9.0	8.7	11.2	11.7	12.3
Soft White Club															
CALORWA	14.0	13.2	14.0	12.1	9.3	13.5	14.8	11.5	11.4	11.4	9.8	9.4	11.2	12.9	12.0
WA7902	12.6	12.2	13.1	12.2	8.7	12.3	12.8	11.0	11.0	11.1	8.3	8.8	10.2	11.7	11.1
WA7904	14.0	14.1	14.9	12.3	10.9	13.0	14.4	12.2	12.7	12.1	9.3	8.8	11.0	13.0	12.2
NURSERY MEAN	13.7	13.1	14.2	12.3	9.9	13.4	13.9	11.5	11.6	11.5	9.1	8.8	11.0	12.3	11.8
CV %	1.2	*	1.7	5.5	4.6	10.7	5.2	3.1	1.6	9.8	5.8	4.7	6.1	2.1	5.6
LSD @ .10	0.2	*	0.3	0.9	0.6	2.0	1.0	0.5	0.2	1.6	0.7	0.6	0.9	0.4	0.3

2001 WSU Spring Wheat Variety Trial Summary (Hard Red, Hard White) - YIELD

VARIETY	HORSE HEAVEN	LIND FALLOW	LAMONT	WALLA WALLA	DAYTON	ST. JOHN	DUSTY	ALMIRA	MAYVIEW	REARDAN	FARMINGTON	FAIRFIELD	PULLMAN	ROYAL SLOPE	VARIETY MEAN
Hard Red Common															
BUTTE 86	15.3	18.1	13.6	27.1	39.8	47.2	54.2	50.9	47.0	57.6	63.8	71.5	75.7	62.1	45.6
BZ9M99-1019	16.4	9.6	10.9	31.2	42.5	46.7	45.8	48.7	51.5	68.7	65.6	77.4	78.9	86.1	47.6
EXPRESS	.	.	.	.	.	.	.	.	.	.	.	.	.	87.4	87.4
GENMILLS BR2306	20.3	18.7	21.5	33.6	44.4	38.4	55.0	52.1	34.1	70.4	68.4	85.1	83.2	95.8	51.5
HANK	10.2	11.9	13.0	34.1	45.2	48.8	48.4	54.2	60.3	65.2	65.2	81.3	88.6	96.6	50.5
JEFFERSON	17.8	17.0	19.9	33.6	44.1	45.2	44.3	52.4	59.6	67.1	65.7	82.8	85.8	93.1	52.0
PRONTO	.	.	.	.	.	.	.	.	.	.	.	.	.	76.4	76.4
SCARLET	16.9	20.7	26.7	35.0	41.2	51.3	59.5	55.6	59.2	63.7	72.3	81.9	87.4	97.8	53.9
SEEDEX HR	23.4	20.3	27.4	22.5	50.4	38.0	46.0	51.6	68.6	63.5	57.3	77.0	84.3	112.1	53.0
TARA	11.3	11.5	14.0	31.8	42.9	45.7	51.8	53.5	48.5	66.7	72.3	83.5	87.6	72.0	49.0
WA7839	13.7	12.4	16.2	30.0	44.6	47.8	54.7	51.6	55.4	67.2	69.6	78.8	79.1	80.6	49.4
WA7859	18.6	19.2	19.9	32.5	43.1	39.6	60.4	55.2	48.8	59.7	75.0	78.5	81.4	87.4	51.4
WA7860	14.5	16.9	20.6	29.7	40.2	43.9	48.4	56.0	37.3	69.2	64.9	76.5	81.0	78.2	48.4
WA7875	18.5	18.6	18.3	29.6	44.5	44.4	47.6	51.3	55.1	59.5	65.7	75.5	84.0	89.2	50.1
WA7892	12.3	16.9	18.1	26.8	42.5	36.9	40.5	52.6	54.6	61.2	67.9	78.1	81.6	87.7	48.4
WA7893	18.3	14.9	21.9	30.6	39.8	49.2	43.4	48.2	46.0	66.9	66.1	80.0	83.4	81.8	49.3
WESTBRED 926	12.4	8.9	16.0	31.3	44.8	41.1	41.9	51.7	53.5	65.2	64.3	80.5	79.5	77.0	47.7
Hard White Common															
455	14.1	15.2	18.2	27.7	44.4	34.3	61.4	54.3	63.2	58.3	69.1	83.9	82.6	93.1	51.4
GENMILLS 40002	14.7	13.2	8.7	35.4	37.1	50.5	44.2	52.0	50.0	63.5	62.7	80.2	81.7	85.9	48.6
GENMILLS 40016	11.9	12.1	10.4	30.9	40.2	46.7	45.9	50.2	56.0	62.6	68.3	78.0	75.6	77.8	47.6
GENMILLS 40019	15.4	15.4	12.1	31.6	40.9	50.1	48.3	47.3	58.4	60.0	66.2	86.3	88.0	86.6	50.5
GENMILLS 40020	17.4	12.6	13.2	33.5	43.5	43.5	47.5	55.9	61.8	68.5	68.0	85.5	85.1	77.2	50.3
ID377S	18.0	19.6	28.4	30.4	44.5	41.4	63.1	62.2	77.4	65.2	69.5	80.0	87.2	112.8	57.1
ID560	.	.	.	.	.	.	.	.	.	.	.	.	.	114.5	114.5
LOLO	16.1	20.3	24.9	33.2	50.3	44.8	72.0	65.1	77.4	65.0	70.5	88.9	92.1	114.5	58.3
MACON	13.9	16.3	16.5	31.2	42.5	39.5	46.5	54.3	46.2	66.3	66.7	82.7	86.7	101.0	50.7
WA7900	11.5	17.1	16.7	34.6	42.4	41.6	51.2	55.6	46.4	69.1	68.9	80.5	84.0	98.2	51.3
WA7901	13.6	19.7	17.8	30.7	42.3	46.7	47.1	46.7	58.0	65.5	64.0	83.2	88.1	105.7	52.1
WA7914	15.7	20.4	12.1	27.4	46.8	42.4	50.0	52.8	66.0	65.0	68.4	88.0	85.5	126.6	54.8
WINSOME	20.2	21.1	30.7	31.9	46.7	38.7	63.8	58.7	75.1	63.4	68.8	86.4	92.2	105.0	57.3

2001 WSU Spring Wheat Variety Trial Summary (Hard Red, Hard White) – TEST WEIGHT

VARIETY	HORSE HEAVEN	LIND FALLOW	LAMONT	WALLA WALLA	DAYTON	ST. JOHN	DUSTY	ALMIRA	MAYVIEW	REARDAN	FARMINGTON	FAIRFIELD	PULLMAN	ROYAL SLOPE	VARIETY MEAN
Hard Red Common															
BUTTE 86	60.8	61.1	59.7	57.4	62.8	57.9	60.3	60.5	62.1	60.0	59.6	62.7	61.5	62.8	60.6
BZ9M99-1019	60.8	59.8	60.0	56.3	62.6	58.4	60.4	60.0	62.4	59.8	58.6	63.1	61.8	62.7	60.4
EXPRESS	.	.	.	.	.	.	.	.	.	.	.	.	.	62.8	62.8
GENMILLS BR2306	61.1	61.6	60.0	55.5	61.4	54.6	58.6	61.6	57.2	59.3	56.6	61.8	59.6	62.8	59.3
HANK	60.6	59.6	59.5	54.6	61.3	57.7	59.2	60.1	61.2	58.1	55.2	61.6	60.3	62.6	59.3
JEFFERSON	61.1	61.0	60.2	55.9	61.9	57.3	58.5	60.8	61.9	59.8	58.1	62.7	60.9	62.8	60.2
PRONTO	.	.	.	.	.	.	.	.	.	.	.	.	.	62.5	62.5
SCARLET	59.4	59.7	59.3	55.0	61.6	57.1	58.2	60.3	61.4	58.0	57.7	62.2	60.0	62.9	59.4
SEEDEX HR	54.9	58.6	60.3	49.8	60.9	56.3	56.9	59.7	61.7	56.0	54.1	60.3	58.6	61.6	58.0
TARA	59.3	58.0	58.9	56.5	62.0	58.7	59.6	60.4	61.7	59.5	58.9	62.4	61.6	61.6	59.9
WA7839	61.1	60.0	59.7	55.6	62.2	58.5	61.1	60.6	61.8	58.9	57.8	62.0	60.5	63.2	60.1
WA7859	60.0	60.7	60.2	57.6	61.0	55.2	60.7	60.5	61.0	57.9	58.5	61.1	60.4	63.2	59.8
WA7860	60.3	61.0	60.3	55.4	61.2	56.9	58.6	61.6	60.0	60.1	57.0	62.7	61.5	63.3	60.0
WA7875	60.3	60.8	60.3	57.4	62.0	56.7	58.6	60.3	61.8	59.2	58.4	62.2	61.3	62.6	60.1
WA7892	58.8	59.2	59.1	53.9	60.1	55.3	56.3	59.4	61.2	58.2	57.8	61.5	60.8	62.3	58.9
WA7893	60.2	60.4	60.3	55.3	60.8	56.8	57.8	60.3	61.1	59.1	57.5	61.6	60.6	63.2	59.6
WESTBRED 926	59.8	59.4	59.1	56.0	61.5	55.9	59.4	59.5	61.3	57.7	56.6	61.2	59.8	62.7	59.3
Hard White Common															
455	58.1	58.8	59.5	54.5	62.2	55.9	59.3	59.7	61.9	57.9	57.2	62.3	60.5	62.7	59.4
GENMILLS 40002	61.1	60.5	59.5	56.8	62.4	59.2	60.4	60.0	61.8	60.0	58.2	63.5	62.0	64.1	60.7
GENMILLS 40016	61.2	61.0	59.8	59.4	63.5	60.2	61.1	62.6	63.3	61.0	60.1	63.3	62.8	64.0	61.7
GENMILLS 40019	60.4	61.0	60.1	55.2	63.1	58.9	59.4	60.5	63.0	58.8	57.3	63.2	62.0	63.9	60.5
GENMILLS 40020	60.5	60.5	61.0	57.9	63.6	57.5	60.7	62.0	63.7	60.1	60.2	63.8	62.8	63.9	61.3
ID377S	59.1	60.6	60.7	54.9	62.7	56.2	60.0	62.0	63.3	57.9	57.4	61.3	61.0	63.6	60.1
ID560	.	.	.	.	.	.	.	.	.	.	.	.	.	63.9	63.9
LOLO	60.5	60.8	60.6	56.1	63.3	58.6	61.9	62.3	63.3	58.8	58.6	63.1	61.5	64.9	61.0
MACON	60.6	60.4	60.6	53.7	61.2	54.8	57.2	61.1	58.7	58.4	56.3	61.9	61.2	63.4	59.2
WA7900	60.8	60.7	60.7	56.1	63.0	55.8	59.1	61.4	61.1	59.5	58.3	63.0	61.4	64.3	60.4
WA7901	60.1	61.0	60.5	55.9	62.8	57.0	59.6	61.5	62.5	59.4	58.4	63.0	61.7	64.4	60.6
WA7914	61.3	61.2	59.8	55.5	62.6	56.8	58.0	61.9	62.6	59.7	56.9	63.8	61.6	64.9	60.4
WINSOME	59.3	61.1	60.9	53.1	61.6	55.3	60.0	61.5	62.3	57.2	56.8	61.0	60.3	63.1	59.6
Spring Durum															
GENMILLS 90009	.	.	.	.	.	.	.	.	.	.	.	.	.	61.9	61.9
UTOPIA	60.0	58.8	56.5	56.0	60.9	55.3	59.0	60.1	60.4	59.8	59.2	63.1	61.7	62.4	59.5
NURSERY MEAN	60.1	60.3	59.9	55.6	62.0	57.0	59.3	60.8	61.6	58.9	57.8	62.3	61.1	63.2	60.0
CV %	*	0.8	1.0	2.2	0.7	3.0	3.4	1.0	0.7	1.8	1.7	1.0	1.0	0.7	1.7
LSD @ .10	*	0.6	0.8	1.7	0.6	2.3	2.8	0.8	0.6	1.5	1.3	0.9	0.8	0.7	0.6

2001 WSU Spring Wheat Variety Trial Summary (Hard Red, Hard White) - % PROTEIN

VARIETY	HORSE HEAVEN	LIND FALLOW	LAMONT	WALLA WALLA	DAYTON	ST. JOHN	DUSTY	ALMIRA	MAYVIEW	REARDAN	FARMINGTON	FAIRFIELD	PULLMAN	ROYAL SLOPE	VARIETY MEAN
Hard Red Common															
BUTTE 86	15.4	16.5	18.0	14.7	12.2	14.8	14.6	14.9	14.4	12.7	14.5	11.3	15.1	17.0	14.6
BZ9M99-1019	16.8	17.9	18.7	15.6	12.8	15.2	16.2	15.6	15.4	12.6	15.5	11.2	14.9	15.9	15.2
EXPRESS	.	.	.	.	.	.	.	.	.	.	.	.	.	15.9	15.9
GENMILLS BR2306	14.1	16.0	16.0	14.1	11.2	16.2	14.2	13.5	13.9	11.3	14.3	10.4	12.7	14.6	13.7
HANK	17.7	18.0	18.7	15.1	12.2	13.4	15.5	14.4	14.0	11.5	15.4	10.4	13.4	15.7	14.5
JEFFERSON	15.8	17.0	17.7	14.9	12.5	15.2	14.6	14.8	14.0	11.9	14.5	10.1	13.6	14.8	14.3
PRONTO	.	.	.	.	.	.	.	.	.	.	.	.	.	16.7	16.7
SCARLET	15.7	16.8	17.7	14.5	12.7	14.0	15.3	14.2	13.7	12.3	14.0	10.9	13.8	15.3	14.3
SEEDEX HR	14.3	14.9	15.0	15.3	11.3	15.6	15.4	12.5	11.9	11.3	14.8	10.2	12.2	12.9	13.3
TARA	17.4	17.7	18.8	14.7	12.3	14.8	15.4	14.4	14.3	11.9	13.4	10.2	13.9	16.4	14.5
WA7839	17.1	17.2	18.4	15.8	12.1	15.2	15.7	14.7	14.4	12.8	14.3	11.2	13.6	15.5	14.7
WA7859	15.6	16.7	17.8	14.5	12.8	17.6	15.8	14.4	14.8	12.4	15.0	11.4	14.9	15.3	14.9
WA7860	16.1	17.1	17.7	15.1	11.5	15.4	15.1	13.4	13.9	11.5	14.3	9.8	13.5	16.0	14.2
WA7875	15.3	16.7	17.3	14.6	11.7	15.1	15.3	14.3	14.1	12.4	14.6	11.4	14.0	15.8	14.4
WA7892	17.4	17.6	18.6	15.7	13.6	15.4	15.3	14.5	14.2	11.7	14.2	11.2	13.4	14.9	14.7
WA7893	16.4	17.2	17.5	14.9	12.3	14.2	15.2	14.3	14.2	11.9	14.2	10.3	13.2	14.9	14.2
WESTBRED 926	17.1	17.9	18.4	15.3	12.8	16.5	16.3	15.0	14.4	12.7	15.2	11.2	13.9	16.1	15.1
Hard White Common															
455	15.7	15.7	16.1	14.0	12.3	15.6	14.5	13.4	13.2	12.2	13.3	10.8	12.6	13.3	13.7
GENMILLS 40002	16.2	16.7	17.6	14.6	11.5	14.3	15.6	14.1	13.2	12.0	14.4	9.9	13.4	15.0	14.1
GENMILLS 40016	16.0	16.1	17.3	13.9	11.4	13.5	15.1	13.7	14.0	12.2	13.3	11.1	13.6	15.2	13.9
GENMILLS 40019	15.9	15.7	16.5	14.7	12.5	13.0	14.9	14.7	13.4	11.8	13.8	10.2	12.9	13.7	13.7
GENMILLS 40020	15.0	16.1	16.5	14.2	11.6	14.6	14.6	13.2	12.8	11.9	13.5	11.0	13.2	15.7	13.7
ID377S	15.7	15.9	16.3	14.3	12.2	15.9	14.5	12.6	13.0	12.1	13.7	11.0	13.2	13.1	13.7
ID560	.	.	.	.	.	.	.	.	.	.	.	.	.	12.6	12.6
LOLO	15.8	15.2	16.2	13.8	12.3	14.9	14.1	12.6	13.0	12.0	13.3	10.1	12.8	13.1	13.4
MACON	15.6	15.7	15.8	14.0	11.1	15.1	14.0	12.6	12.4	11.1	13.7	9.8	12.2	13.8	13.2
WA7900	16.2	15.6	16.4	13.1	10.9	15.5	13.6	12.4	12.1	10.8	12.6	9.8	12.6	14.1	13.1
WA7901	16.0	15.0	16.1	14.0	11.3	14.2	14.1	12.9	12.4	11.4	13.3	9.7	12.5	13.3	13.2
WA7914	14.9	15.1	16.4	12.8	11.8	13.8	14.7	13.4	12.3	11.5	13.6	9.5	12.4	13.4	13.2
WINSOME	14.1	14.5	14.5	14.1	11.9	15.4	12.9	12.5	12.0	11.4	12.8	10.3	12.1	12.5	12.9
Spring Durum															
GENMILLS 90009	.	.	.	.	.	.	.	.	.	.	.	.	.	16.2	16.2
UTOPIA	14.4	14.4	15.5	13.9	12.1	16.3	15.6	13.8	14.1	11.5	14.3	11.0	13.4	15.1	13.9
NURSERY MEAN	15.8	16.3	17.1	14.5	12.0	15.0	14.9	13.8	13.6	11.9	14.1	10.5	13.3	14.7	14.0
CV %	*	1.0	1.6	4.4	3.9	10.9	5.4	2.9	2.2	5.7	5.1	6.0	4.0	2.5	4.9
LSD @ .10	*	0.2	0.4	0.9	0.6	2.2	1.1	0.6	0.4	0.9	1.0	0.9	0.7	0.5	0.4

2001 WSU Spring Barley Variety Trial Summary - YIELD

VARIETY	ANATONE	LAMONT	WALLA WALLA	DAYTON	ST. JOHN	MAYVIEW	DUSTY	ALMIRA	FAIRFIELD	REARDAN	FARMINGTON	PULLMAN	ROYAL SLOPE	VARIETY MEAN
2-ROW														
85AB2323	1582	1395	2963	3006	3405	3482	4341	4451	5066	4985	5151	6096	7696	4124
98NZ015	824	1782	2123	2790	3341	3979	4213	3641	5141	4664	5196	5785	7193	3898
98NZ223	1321	2203	2729	2763	3497	3782	3944	4011	5215	5175	4831	6477	6795	4057
98NZ234	1291	1867	2693	2548	3336	3228	3898	3987	4950	4348	4714	5706	7000	3813
98NZ533	1261	2009	2520	2094	3024	3637	3111	4404	5028	4922	4753	6071	6652	3807
BANCROFT	1574	1232	2510	2743	3394	2642	4022	4153	4576	4830	4797	5983	6746	3785
BARONESSE	1552	2040	2944	2729	3517	3878	4463	4056	4945	4724	5103	6205	7291	4111
BCD 47	1318	1189	2736	2600	3096	3140	2842	3562	4556	4599	4719	5692	6996	3619
BZ 594-20	1657	1522	2833	2873	3278	3028	3019	3300	3971	4906	4747	5786	7733	3743
CAMAS	1464	1983	3002	2869	3126	3397	3625	3782	5152	5197	5203	6417	7326	4042
FARMINGTON	1098	1429	2948	2607	3119	3479	3506	4643	5071	4756	5164	6062	7333	3939
GALLATIN	1464	1823	2689	2580	3235	3469	3790	4027	4600	4555	4989	5745	6954	3840
H3869224	1589	1602	2801	2945	3127	3361	4792	4070	4570	4637	4805	5932	6419	3896
HARRINGTON	1136	2190	3079	2524	3047	2967	4958	4163	4806	4616	5096	5844	6839	3943
JERSEY	1200	1364	2666	3584	3236	3252	5123	3631	5250	4649	4996	6115	7342	4031
LEWIS	1601	2210	2521	2986	3348	3307	3990	3499	4412	4896	5030	6151	6564	3886
MENTOR	1385	1842	2827	2784	3140	4518	3454	3203	5063	5135	4978	5680	6916	3917
ORCA	1088	1528	2844	2115	3176	3252	2960	3444	4334	4747	4681	4894	7272	3564
PB1-95-2R-517	1027	1212	2739	2656	3140	3469	2844	3471	4568	4670	5049	6038	7322	3708
PB1-95-2R-A629	1213	1262	2952	2574	3086	4308	3980	3990	4896	5097	4983	6074	6986	3954
PONGO	1661	2152	2563	3059	2948	4281	4092	3822	5223	4439	5207	6289	7428	4090
VALIER	1492	1934	3035	2772	3190	3593	3932	4481	4373	5329	4377	5892	7242	3972
WA 10138-96	1419	1165	2852	3126	3441	2941	3912	3840	4850	4591	5093	6153	7075	3881
WA 10144-96	1286	1992	2598	3045	2919	3178	4009	4294	5017	4331	5036	6086	7625	3955
WA 10147-96	1477	1865	2737	2733	3154	3347	3069	4426	5015	4748	5066	6304	7454	3953
WA 10467-97	1083	1712	2502	3009	3199	3053	2250	4270	4995	5025	4931	6079	6890	3769
WA 13898-97	1285	1880	2897	2820	3388	3088	3687	3835	4956	5023	4988	5628	6741	3863
WA 7478-97	1446	1636	2469	3190	2983	2989	4252	3894	5102	4663	5016	6333	7003	3921
WA 8601-97	1193	1456	2656	3031	3340	3426	3591	4238	5258	5589	4635	6691	7287	4030
WA 8608-97	1281	2002	2955	2888	3122	3120	4328	3921	5087	5133	5000	6174	7518	4041
WA 8674-96	1593	1728	2810	2939	2897	2638	3580	4403	5068	5183	4815	6380	7140	3936
WA 8682-96	1437	1496	3078	2468	3481	3265	3977	3913	4917	5095	4919	5665	7268	3921
WA 8709-96	1218	1650	3041	2510	3306	3967	2988	3995	4962	4633	4865	6108	7572	3909
WA 8769-96	1351	1430	2630	2967	2834	3016	3229	3503	4996	5041	4915	5792	6642	3719
WA 8792-96	1360	1834	2810	2999	3237	3088	4786	3700	4832	5289	4931	5776	7218	3989
XENA	1676	1886	3139	2726	3411	3491	3377	4132	4710	4714	4752	6358	7717	4007
6-ROW														
MOREX	1752	1043	2904	2456	3303	2195	3650	3281	3643	4366	4844	5148	4865	3342
STEPTOE	1652	1029	2915	3062	3646	3588	4211	3691	4179	4860	4877	5922	7201	3910
TANGO	1322	1197	2346	2307	3090	2894	3742	2860	3806	4553	4214	5127	6361	3371
NURSERY MEAN	1375	1661	2770	2781	3219	3352	3783	3896	4799	4838	4909	5966	7067	3878
CV %	16.1	26.8	8.4	11.6	11.1	16.6	24.2	8.9	6.4	9.3	7.6	4.7	7.6	11.5
LSD @ .10	301	605	315	437	485	759	1243	472	419	610	506	380	730	167

2001 WSU Spring Barley Variety Trial Summary – TEST WEIGHT

VARIETY NAME	ANATONE	LAMONT	WALLA WALLA	DAYTON	ST. JOHN	MAYVIEW	DUSTY	ALMIRA	FAIRFIELD	REARDAN	FARMINGTON	PULLMAN	ROYAL SLOPE	VARIETY MEAN
2-ROW														
85AB2323	50.8	45.3	49.2	52.5	46.0	52.5	52.0	51.0	53.3	50.5	48.6	53.2	55.1	50.8
98NZ015	49.9	47.3	45.1	50.6	45.3	51.2	49.7	49.8	51.1	47.1	44.4	52.4	53.7	49.0
98NZ223	50.5	48.6	45.9	51.7	44.8	51.1	49.2	50.1	52.0	50.2	45.4	52.5	55.0	49.8
98NZ234	48.2	47.3	46.0	51.3	44.2	51.2	50.5	50.2	52.4	48.1	44.9	52.1	54.8	49.3
98NZ533	47.7	47.0	43.9	52.0	44.6	50.1	47.5	49.9	50.9	48.3	45.6	52.0	54.1	48.7
BANCROFT	48.6	45.3	45.3	50.8	45.8	50.5	49.3	50.4	52.4	48.1	49.3	51.3	53.6	49.3
BARONESSE	50.5	47.8	47.1	52.1	45.5	50.8	50.7	50.5	52.1	47.6	44.1	52.0	55.6	49.7
BCD 47	50.7	48.6	48.8	52.1	47.6	52.2	50.0	50.9	53.3	50.9	48.5	52.8	53.9	50.8
BZ 594-20	52.5	48.6	50.6	53.5	49.2	53.4	51.3	50.8	55.1	52.3	52.4	54.8	56.1	52.3
CAMAS	50.5	49.3	49.4	52.4	46.3	52.4	52.0	51.4	53.6	50.2	51.3	54.9	55.2	51.4
FARMINGTON	48.9	48.1	46.7	50.8	47.1	49.8	49.5	49.7	52.6	47.8	46.2	52.0	54.9	49.5
GALLATIN	48.5	47.0	46.8	51.8	46.1	53.1	51.0	51.3	54.0	50.2	50.1	53.5	55.4	50.7
H3869224	49.4	44.9	47.1	51.3	45.3	52.4	52.4	51.4	53.1	49.2	47.6	53.0	55.7	50.2
HARRINGTON	47.4	47.3	46.9	51.1	43.2	49.5	51.0	48.7	51.5	47.8	44.2	51.2	53.8	48.7
JERSEY	50.0	48.0	47.0	51.9	48.0	51.3	52.1	50.2	52.4	49.2	47.2	52.3	53.7	50.2
LEWIS	50.2	49.5	47.4	53.0	48.3	52.8	52.1	50.3	54.3	51.1	49.5	53.8	55.4	51.4
MENTOR	50.2	49.7	46.2	52.2	45.2	51.2	50.4	50.4	51.8	49.6	47.1	51.3	53.4	49.9
ORCA	46.8	46.9	49.5	51.2	46.0	51.6	50.6	48.4	52.3	48.3	48.1	53.2	53.3	49.7
PB1-95-2R-517	47.7	45.6	47.1	51.0	44.2	50.6	48.3	50.0	52.4	49.9	46.5	52.9	55.1	49.3
PB1-95-2R-A629	48.3	48.4	48.6	51.6	45.9	52.1	51.1	51.7	53.5	51.2	45.6	53.0	54.9	50.4
PONGO	48.7	47.7	42.7	50.1	42.3	49.5	47.5	47.1	50.0	45.6	44.9	48.8	53.6	47.6
VALIER	50.5	48.6	48.8	52.0	46.0	51.3	52.1	51.2	53.3	51.4	48.6	52.6	55.0	50.9
WA 10138-96	49.8	45.3	47.2	51.0	46.3	51.1	50.6	50.1	52.5	48.3	47.1	52.7	55.3	49.8
WA 10144-96	48.3	47.9	46.3	51.4	43.9	49.9	49.0	49.4	52.2	46.2	44.6	52.2	54.8	48.9
WA 10147-96	48.9	46.9	46.4	51.6	45.6	50.4	47.4	49.5	52.3	48.7	46.3	52.2	55.1	49.3
WA 10467-97	49.4	47.4	45.9	51.1	46.4	50.3	47.3	49.8	51.9	49.3	46.1	51.6	54.3	49.3
WA 13898-97	51.3	47.6	47.3	52.3	45.5	52.0	50.5	51.2	53.5	50.3	46.1	52.9	55.2	50.4
WA 7478-97	49.7	47.8	45.4	50.8	44.7	50.8	49.2	50.3	51.3	47.1	45.9	52.1	53.4	49.1
WA 8601-97	49.2	45.9	44.5	51.1	45.1	50.0	49.2	49.3	51.2	48.1	45.5	51.6	54.6	48.9
WA 8608-97	49.9	48.1	47.6	50.8	45.1	50.5	50.7	50.3	52.4	49.2	48.2	52.7	55.0	50.0
WA 8674-96	51.1	49.2	48.5	53.1	45.8	52.0	50.4	51.9	54.0	50.5	47.1	54.2	55.6	51.0
WA 8682-96	51.4	48.5	49.0	52.5	47.3	52.2	51.2	50.5	53.4	50.1	47.5	54.0	54.7	50.9
WA 8709-96	51.1	47.4	47.3	52.7	46.0	51.8	48.6	51.0	53.3	49.0	45.9	52.8	55.7	50.2
WA 8769-96	50.8	47.6	46.8	52.6	44.9	51.1	50.3	50.7	53.1	49.7	45.8	52.6	55.0	50.1
WA 8792-96	51.4	48.1	48.2	52.7	48.6	51.6	52.4	50.9	53.2	49.5	47.5	53.3	55.0	50.9
XENA	50.8	49.1	48.6	51.0	46.0	52.2	50.3	49.7	53.4	49.0	50.1	53.3	55.5	50.7
6-ROW														
MOREX	45.7	44.4	48.0	48.4	46.1	50.1	50.8	48.5	51.0	48.4	45.4	50.8	53.2	48.5
STEPTOE	44.3	45.2	46.5	46.4	42.2	48.1	46.4	45.7	48.0	44.8	42.7	47.8	51.7	46.1
TANGO	42.3	44.0	45.9	47.4	42.0	49.3	46.4	45.2	48.1	45.3	43.9	48.3	51.6	46.1
NURSERY MEAN	49.3	47.4	47.1	51.4	45.6	51.1	50.0	50.0	52.4	48.9	46.8	52.3	54.5	49.8
CV %	2.4	3.6	2.7	1.1	3.8	1.9	3.7	1.3	0.9	2.0	4.7	1.0	0.9	2.6
LSD @ .10	1.6	2.3	1.7	0.8	2.3	1.3	2.5	0.9	0.7	1.3	3.0	0.7	0.7	0.5

WASHINGTON AGRICULTURAL STATISTIC SERVICE:

Winter Wheat: Acres Planted by Variety, By Agricultural Districts, Washington, 1999-2001

Class and	Variety	1999 Total	2000 Total	2001 Total 1/	2001 West	2001 Central	2001 N. East	2001 E.Central	2001 S. East
		Acres	Acres	Acres	Acres				
COMMON WHITE	Eltan	402,300	403,600	435,000	-	14,800	1,900	414,700	3,600
	Madsen	535,500	455,800	402,100	400	14,200	71,300	46,000	270,200
	Madsen-Rod*	121,200	124,300	146,200	-	-	2,400	13,500	130,300
	Stephens	123,400	98,200	83,800	3,000	11,700	-	16,900	52,200
	Cashup	57,400	75,100	75,700	2,700	-	-	2,800	69,500
	Eltan-Madsen*	72,400	56,800	53,300	-	-	2,900	48,300	-
	Lambert	22,100	28,900	41,700	-	-	-	-	39,000
	Rod	37,400	25,000	34,500	-	-	-	7,700	25,600
	Lambert-Madsen*	2,200	13,100	34,200	-	-	-	-	34,200
	Lewjain	51,300	33,400	29,700	-	-	3,200	26,500	-
	Albion	-	-	19,400	-	-	4,000	8,800	6,500
	Hill 81-Madsen-Rod*	8,300	10,000	12,500	-	-	-	-	12,500
	Malcolm	18,400	14,500	10,700	-	-	-	-	2,300
	WPB 470	18,500	13,700	10,100	-	-	-	2,700	6,700
	Hill 81	13,900	14,600	8,900	-	-	2,900	500	2,800
	Eltan-Lewjain*	6,000	5,500	8,300	-	-	-	8,300	-
	Eltan-Rod*	-	1,900	7,400	-	-	-	7,400	-
	Madsen-Rod-Stephens*	5,700	7,100	7,200	-	-	-	-	7,200
	Lambert-Rod*	2,500	3,800	5,500	-	-	-	-	5,100
	Gene	-	1,000	4,600	-	-	-	-	-
	Madsen-Rod-WPB470*	-	-	3,600	-	-	-	-	3,600
	Madsen-Stephens*	14,700	8,000	3,200	-	800	-	-	2,100
	Hill 81-Madsen*	1,900	2,800	3,100	-	-	-	-	2,700
	Quantum 7817	900	1,100	3,100	-	-	-	1,000	-
	Daws	8,600	5,300	2,900	-	-	2,300	-	-
	Cashup-Madsen*	-	3,900	2,600	-	-	-	-	2,200
	Lambert-Madsen-Rod*	3,400	1,700	2,600	-	-	-	-	1,800
	Sprague	5,100	1,500	2,500	-	-	-	-	-
	Madsen-Rod-Eltan	3,900	6,000	2,500	-	-	-	2,200	-
	Lewjain-Madsen*	5,300	3,500	2,100	-	-	-	2,100	-
	Weatherford	-	-	2,100	-	-	-	-	2,000
	Basin	1,600	2,000	1,600	-	-	-	-	1,400
	Eltan-Lewjain-Madsen	-	-	1,500	-	-	-	-	-
	Cashup-Rod*	700	5,800	1,100	-	-	-	-	1,100
	Rod-Stephens*	2,000	8,500	-	-	-	-	-	-
	MacVicar	4,200	5,300	-	-	-	-	-	-
	Other Common White	24,300	13,700	11,400	900	13,700	5,400	12,600	11,600
	Total Common White	**1,589,000**	**1,455,400**	**1,476,700**	**7,000**	**55,200**	**96,300**	**622,000**	**696,200**
WHITE CLUB	Rely	101,800	163,300	88,200	-	-	-	85,600	1,500
	Coda	400	22,900	63,500	-	2,200	-	54,500	5,600
	Edwin	-	-	39,100	-	-	-	37,500	-
	Moro	8,100	21,300	15,900	-	-	-	14,900	-
	Hiller	7,700	11,700	9,600	-	-	-	6,100	3,000
	Bruehl	-	-	4,400	-	-	-	3,800	-
	Hyak	4,600	500	3,800	-	-	-	3,800	-
	Tres	8,800	1,500	1,400	-	-	-	1,400	-
	Rohde	6,700	7,700	900	-	-	-	-	
	Crew	-	2,600	-	-	-	-	-	-
	Other White Club	4,500	3,500	1,800	-	1,500	800	3,700	2,700
	Total White Club	**142,600**	**235,000**	**228,600**	**-**	**3,700**	**800**	**211,300**	**12,800**
HARD RED	Hatton	30,400	37,800	34,500	-	4,800	-	29,500	-
	Finley	7,400	31,400	32,100	-	28,400	-	3,700	-
	Buchanan	17,500	31,400	20,900	-	17,700	-	3,200	-
	Weston	35,100	7,300	10,700	-	9,000	-	1,700	-
	Symphony	26,400	15,000	10,400	-	3,300	-	5,700	1,400
	Quantum (Q542)	27,200	22,400	8,200	-	-	-	7,800	-
	Estica	4,200	4,100	8,000	-	-	-	8,000	-
	Wanser	-	-	4,200	-	4,100	-	-	-
	Columbia 1	-	-	3,100	-	-	-	-	3,100
	Boundary	-	-	3,100	-	-	-	-	-
	Other Hard Red	8,600	10,200	9,500	-	2,800	1,900	6,100	2,500
	Total Hard Red	**168,400**	**159,600**	**144,700**	**-**	**70,100**	**1,900**	**65,700**	**7,000**
TOTAL WINTER WHEAT		**1,900,000**	**1,850,000**	**1,850,000**	**7,000**	**129,000**	**99,000**	**899,000**	**716,000**

*1/ The sum of the districts by variety may not add to the state total to avoid disclosure of individual operations. * Denotes mixtures. - Not estimated or combined with the "Other" category.*

WASHINGTON AGRICULTURAL STATISTIC SERVICE:

Spring Wheat: Acres Planted by Variety, By Agricultural Districts, Washington, 1999-2001

Class and Variety	1999 Total	2000 Total	2001 Total 1/	2001				
				West	Central	N. East	E. Central	S. East
	Acres	Acres	Acres			Acres		
COMMON WHITE								
Alpowa	220,900	283,700	287,400	-	26,700	22,400	141,600	96,700
Wakanz	5,200	18,800	33,900	-	-	-	-	33,300
Penawawa	63,300	24,700	26,000	-	4,200	-	15,100	3,900
Wawawai	95,500	40,400	25,500	-	-	2,100	-	22,600
Edwall	20,800	16,500	13,200	-	-	400	2,500	10,300
Westbred Vanna	10,400	22,500	11,500	-	-	-	-	11,100
Challis	-	-	6,700	-	-	-	800	5,900
Alpowa-Edwall*	-	-	5,000	-	-	-	-	2,400
Wadual	5,700	3,600	3,400	-	-	-	3,400	-
Zak	-	-	3,300	-	-	-	1,900	1,300
Wakanz-Alpowa*	-	-	2,100	-	-	-	-	2,100
Fielder	-	-	900	-	-	-	-	-
Vanna-Westbred Sprite*	-	800	-	-	-	-	-	
White Club	1,500	7,300	3,600	-	-	-	1,900	1,700
Other Common White	5,300	9,600	2,600	1,000	800	1,900	5,400	1,700
Total Common White 2/	**448,500**	**427,900**	**425,100**	**1,000**	**31,700**	**26,800**	**172,600**	**193,000**
HARD RED								
Westbred 926	41,600	69,700	53,700	-	1,300	5,400	4,600	42,400
Westbred Express	35,400	45,200	48,000	-	1,500	-	29,700	16,800
Scarlet	-	7,500	44,400	-	28,800	-	13,300	2,300
Hank	-	-	11,900	-	-	2,600	3,600	5,400
Butte 86	18,500	18,300	8,600	-	3,300	-	5,300	-
Jefferson	-	-	7,700	-	-	-	4,500	3,200
Spillman	15,700	16,400	7,500	-	-	-	7,500	-
Westbred 906R	3,100	3,700	4,500	-	-	-	-	3,000
Yecora Rojo	3,200	2,000	4,000	-	3,400	-	-	-
Westbred 936	11,600	4,600	3,300	-	-	-	-	3,100
Pronto	-	-	2,600	-	300	-	2,300	-
Sunstar (II)	-	-	1,600	-	-	-	1,600	-
Kulm	16,600	2,700	-	-	-	-	-	-
Wampum	3,100	1,400	-	-	-	-	-	-
Amidon	-	800	-	-	-	-	-	-
Other Hard Red	7,900	400	13,000	-	600	100	13,500	1,400
Total Hard Red	**165,800**	**172,700**	**210,800**	**-**	**39,200**	**8,100**	**85,900**	**77,600**
HARD WHITE								
Idaho 377S	8,400	20,300	3,500	-	-	-	-	2,400
Winsome	-	3,800	500	-	-	-	-	-
Other Hard White	2,300	300	100	-	100	100	1,500	-
Total Hard White	**10,700**	**24,400**	**4,100**	**-**	**100**	**100**	**1,500**	**2,400**
TOTAL SPRING WHEAT	**625,000**	**625,000**	**640,000**	**1,000**	**71,000**	**35,000**	**260,000**	**273,000**

1/ *The sum of the districts by variety may not add to the state total to avoid disclosure of individual operations.*
2/ *"Total Common White" includes an estimated 1,500 acres of White Club spring varieties in 1999, 7,300 acres in 2000, and 3,600 in 2001 at both District and State levels.*
* *Denotes mixtures.*
\- *Not estimated or combined with the "Other" category.*

WASHINGTON AGRICULTURAL STATISTIC SERVICE:

Barley: Acres Planted By Variety, By Agricultural District, Washington, 2001

Type/Variety	West	Central	Northeast	East Central	Southeast	State Total 1/	% of Total 2/
				Acres			Percent
FEED BARLEY							
Baronesse	800	3,200	27,700	95,200	187,000	313,900	73.0
Camelot	-	-	3,200	17,800	4,700	26,000	6.1
Gallatin	-	-	-	6,200	5,400	13,200	3.1
Lewis	-	2,500	600	2,000	-	5,100	1.2
Xena	-	-	-	4,400	-	5,100	1.2
Steptoe	800	1,000	-	500	-	3,000	0.7
Meltan	-	-	-	2,100	-	2,500	0.6
Baronesse-Camelot*	-	-	-	2,400	-	2,500	0.6
Belford	-	1,000	100	200	600	1,900	0.4
Boyer	200	-	-	-	900	1,500	0.4
Hesk	-	-	-	-	-	900	0.2
CDC Stratus	-	-	-	-	200	900	0.2
Westford	-	-	200	-	-	400	0.1
Columbia	-	-	-	200	-	300	0.1
Haybet	-	-	-	-	300	300	0.1
Other Feed Barley	1,400	2,300	2,000	1,800	5,500	6,900	1.6
Total Feed Barley	**3,200**	**10,000**	**33,800**	**132,800**	**204,600**	**384,400**	**89.4**
MALTING BARLEY							
Harrington	-	-	6,400	3,200	23,500	33,100	7.7
Morex	-	-	4,400	-	1,700	6,400	1.5
Garnet	-	-	1,200	300	1,400	2,900	0.7
Crest	-	-	-	-	900	900	0.2
Legacy	-	-	500	-	-	900	0.2
Other Malting Barley	-	-	300	700	1,100	1,400	0.3
Total Malting Barley	-	-	**12,800**	**4,200**	**28,600**	**45,600**	**10.6**
TOTAL ALL BARLEY	**3,200**	**10,000**	**46,600**	**137,000**	**233,200**	**430,000**	**100.0**

1/ The sum of the district may not add to the state total to avoid disclosure of individual operations.
2/ Sum of the percentages may not add due to rounding.
- Not estimated or combined with the "Other Barley" category.

NEW DIRECTIONS OF THE GRAIN LEGUME BREEDING PROGRAM

F.J. Muehlbauer, K.E. McPhee, W. Chen, R.W. Short, J.C. Coker and S.L. McGrew

The grain legume breeding program is focused on producing new improved cultivars of spring-sown dry pea, lentil, chickpea and winterhardy pea and lentil. Emphasis has been placed on the development of edible types of winter peas and winter lentils that can be direct-seeded in the fall into cereal stubble. All types of edible grain legumes must be environmentally adapted, high yielding and market acceptable. Meeting these demands has necessitated accelerating the breeding process. Increased use of greenhouse screening for early generation breeding material coupled with intense field screening of selected material has resulted in dramatically reducing the overall time from initial parental selection and cross pollination to cultivar release. Promising selections are often increased during the winter months in Arizona to shorten the time from variety release to commercial field production. The breeding efforts directed at each of these crops are described below.

Dry Peas

Dry peas are an important rotational crop in the cereal-based production systems of the Palouse region of eastern Washington and northern Idaho. The crop provides an alternative to cereals and is considered necessary to break disease cycles, allow grassy weed control and increase the fertility status and tilth of the soil. A number of diseases attack the pea plant of which root rots, wilts, viruses and powdery mildew can be of epidemic proportions. Progress has been made under previous industry supported projects in the development of dry pea breeding lines with multiple disease resistance, particularly to root rot, wilt, powdery mildew and viruses (mainly bean leaf roll and pea enation mosaic).

Market exploration for the marrowfat type pea indicates that this type of pea could soon play an important role in the Pacific Northwest. Marrowfat peas are green in color and approximately twice the size of the traditional smooth green peas (35-40 vs. 18-22 gm/100 seed). They are oblong and have an irregular or dimpled seed surface. They are used in soups in the United Kingdom, and in East Asia they are used in the snack food industry. Snack processing includes soaking the seed and frying it in hot vegetable oil until crunchy and then adding seasonings to the seed surface for flavor. Market requirements include extremely large seed size, dark green color (<30% bleach) and excellent seed coat integrity.

In 2000, two new cultivars were released, 'Lifter' and 'Franklin'. They both have the semi-dwarf growth habit and normal leaf morphology. Yield potential of Lifter and Franklin is superior to 'Joel' and 'Columbian' and they have durable, green cotyledon color, which is resistant to seed bleaching. Due to the normal leaf morphology and poor stem structure lodging will occur prior to harvest.

The afila leaf trait has been incorporated into many of the breeding lines over the past several years to confer an upright growth habit conducive to direct harvesting with a wheat header. Several lines are currently in the advanced yield trials at four locations and are being considered for release. One line in particular, PS610152, has shown excellent yield potential, resistance to seed bleach and maintains an upright growth habit through harvest. This line has been approved through the Washington State University Legume Variety Release Committee for preliminary increase of breeder seed. Additional testing of this line is necessary to support full release of this breeding line.

Future objectives of the dry pea breeding program include continued improvement in yield potential, bleach resistance, upright growth habit and multiple disease resistance. Development of an orange-seeded pea that is adapted to the Pacific Northwest and a marrowfat cultivar suited to the snack food industry are currently a major focus of the program.

Lentils

The lentil industry of the U.S. competes in the world market and must have cultivars that produce acceptable quality of the various market classes. For that reason, cultivars with improved yields and seed quality are essential to maintaining and improving competitiveness. Until very recently, the Palouse region produced only one type of lentil, the so-called Chilean type ('Brewer') with large, yellow cotyledons. Indications now are that several types can be produced and sold in various markets both domestically and worldwide. An exceptionally large yellow-seeded lentil with uniformly green seed coats is needed by the industry to compete in markets in the Mediterranean region. In addition to a large yellow lentil cultivar, the industry would benefit from a small Turkish red type of lentil.

Crimson was released in 1990 as a Turkish red type. 'Mason' a large yellow cotyledon type, was released in 1997, and has exceptionally large seed size and is higher yielding than Brewer. It also produces large amounts of residue that is beneficial for soil conservation. Recently, two new lentil varieties were proposed for release and include 'Pennell', a large-seeded type with good standing ability, large non-mottled seeds and higher yields and 'Merrit', a large-seeded high yielding variety that is intended as a replacement for 'Brewer'. Additional work toward an 8-9 mm diameter lentil is underway. Improved selections are being tested in 1999 and one or more will be proposed for release to the industry this fall. The improved selection will have better standing ability, higher yields and increased amounts of residues.

Winter Lentil

A breeding program for winter lentil has been established and many breeding lines have been identified with excellent winter hardiness. Three main types of winter lentil are being developed, large red, large yellow and small yellow cotyledon types. We have recently proposed a red cotyledon winter lentil for increase for possible release to the industry this year. The line, LC9979010, has excellent winter hardiness and is targeted for direct seed cropping systems. This winter hardy lentil has improved yields over spring sown varieties. Samples taken to India reportedly have acceptable quality for that market. The lines are small seeded and similar to 'Crimson' and should fit well in the decortication and splitting process. In addition to the winter lentil release, we have proposed another line, LC760209C, for increase for possible release next year. The line is a "Castillion" type that has appeal in the Spanish market. It is large seeded with some mottling.

Chickpea (Garbanzo Beans)

Ascochyta blight is a devastating disease of chickpea in the Palouse area and has caused serious problems with crop production. Success in the early 1990s led to the development of cultivars such as 'Dwelley' and 'Sanford' making it possible to grow the crop with some assurance that the disease would not be as devastating. In 1997, 'Evans' was released as an earlier flowering and maturing variety with resistance to Ascochyta blight. These three cultivars are the only large-seeded kabuli types with resistance to Ascochyta blight available for production.

Recent market information indicates that there is an increasing demand for the so-called 'Spanish White' type characterized by exceptionally large white seeds. Numerous crosses were made to incorporate Ascochyta blight resistance into the Spanish White type. During the 2000-01 winter season, three Spanish White type selections were increased at Yuma, Arizona, to provide additional seed for yield testing and reduce the time required for release to producers. One of the lines, CA9890233W, has good resistance to blight and relatively large and white seeds.

In addition to the work on the Spanish White type, we have released a selection under the name of 'Sierra'. The variety has good resistance to blight and is 2-3 days earlier to bloom and mature when compared to 'Dwelley'. Sierra also has larger seed size. This variety has been made available in small quantities for the 2002 growing season. We have applied for Plant Variety Protection for Sierra.

Winter Peas

Two types of winter peas are currently being developed. The first is the Austrian winter pea and the second is a white-flowered, clear-seeded pea similar to the spring-sown edible types. The Austrian winter peas are an alternative legume crop on the Camas Prairie of northern Idaho and to a limited extent in southeastern Washington and eastern Oregon. A relatively high proportion of hard seed in the Austrian winter pea has limited its use in the Palouse region. Development of the clear-seeded types will not only reduce the hard seed problem, but will allow greater yields to be attained from each pea crop. Several promising lines have been evaluated for yield potential and seed quality.

Root and foliar diseases have caused a decline in production over the past 10 years. The most serious diseases include soilborne Aphanomyces root rot and infestations of the Ascochyta blight complex and Sclerotinia white mold. The foliar disease problems can be solved through the use of upright plant types that increase air movement through the canopy thereby reducing humidity in the lower canopy. The root disease problem is somewhat more difficult. However, we have established root disease screening nurseries that have the potential to identify genetic material with tolerance to the most important root rotting pathogens. Development of multiple disease resistant varieties is needed if this crop is to continue as an integral part of the cropping systems in the Camas prairie and for expanded production in the Palouse region. The most urgent need is to develop cultivars with resistance to these diseases and with sufficient winterhardiness to be grown in diverse and severe environments. Many crosses have been made with these objectives in mind and are expected to produce superior breeding lines.

'ORCA', A NEW BEAN VARIETY FOR SPECIAL NICHE MARKET

An N. Hang, Matt J. Sibernagel, Phillip N. Miklas and Virginia I. Prest
WSU and ARS Prosser

1. Unique Cultivar Characteristics: Orca ($F_{6:10}$) is derived from the cross A-55/Anasazi bean. It has unprotected dominant *I* gene resistance to bean common mosaic virus (BCMV) and complete resistance to curly top virus (CTV). It is also tolerant to the root rot complex in the seed producing area of the Pacific Northwest. Plants are upright type IIA and lodging resistant. Seed of Orca are black and white mottled, plumb and medium sized (1500 seeds per lb.). This cross made a novelty with high market potential.

2. Use Type: Orca seed has a very attractive black and white mottled pattern with very shiny seed coat. It will use as dry pack for the garden bean growers and for the health food retail market.

3. Description: Orca is an upright short vine bean. It is as tall as most of the black beans. Plant type is very similar to A-55, resistance to lodging and medium to late maturity (100 to 105 days after planting). It adapts to the semi-arid regions, but with irrigation it produces high quality seed yield.

4. To Supplant: Orca is the first US anasazi type black and white bean released. It will replace the photo-periodically sensitive anasazi bean seed grown in the highland of Southwestern states. This cultivar is an annual and can be grown and mature in 100 to 110 days in the Northern states.

Performance Evaluation:

1. Agronomic: Yield is comparable to black bean in some years. Normally it is smaller in yield than black grown at the same location. Seed is much larger than black bean tested in the same year and at same location (20 to 22 vs. 27 to 30 g/100 seeds). Orca is in bloom about 59 to 62 days after planting and is late maturity (Table 1). Plant is upright and possesses a deep root system that is resistant to lodging (score 1.5 in a 1 to 9 scales with 1 = resistance to lodging and 9 is susceptible).

2. Quality: There is a limit data for canning trial available. After cooking the dark part of the seed appears dark maroon similar to its anasazi parent. It is for fresh market as dry pack at the health food store due to its attractive shiny seed coat and a black and white pattern. It has a thick seed coat and easy to thresh and resistance to slitting.

3. Resistance to Disease, Insects, Other: Plants of Orca are upright and lodging resistant, and have unprotected dominant *I* gene resistance to bean common mosaic virus and complete resistance to curly top virus. This cultivar is also tolerant to the root rot complex (*Fusarium, Rhizoctonia* and *Pythium* spp.).

4. Area of Adaptation: Orca is adapted to the bean grown areas where the growing season is about 100 to 110 days. Its growing season is as long as black bean and it can be grown in the black bean producing areas.

Table 1. AGRONOMIC DATA FOR ORCA AND BLACK BEAN GROWN AT WSU RESEARCH FARM, 1993, 1994, 1995, 1996, AND 2001.

Year	Entry	Yield (lb/a)	Seed/lb (NO.)	50% Bloom (Days)	Physiological Maturity (days)	Seed Fill Duration (days)	Yield Efficiency (lb/day)	Seed Fill Efficiency (lb/a/day)	Lodging
1993	92BR3-802(a)	1351	1865	59	125	66	10.81	20.47	1
	92BR3-803	1570	1636	63	125	62	12.56	25.32	1
	92BR3 804(a)	1788	1636	59	125	66	14.30	27.09	1
	92BR3-805	1784	1698	59	125	66	14.27	27.03	1
	92BR3-806	1644	1636	59	125	66	13.15	24.91	1
	92BR3-807	832	1730	59	125	66	6.66	12.61	1
	ORCA	**1790**	**1567**	**50**	**121**	**71**	**14.79**	**25.21**	**1**
	92IS 7315	1731	1516	59	120	61	14.42	28.38	1
	92IS 7333	1585	1694	59	120	61	13.21	25.98	1
	92IS 7334	939	1809	59	120	61	7.82	15.39	1
	UI 906	2528	2218	59	120	61	21.07	41.44	2
	Mean	1552							
	Pr>F	ns							
	Lsd (0.05)	1534							
	CV (%)	58.0							
1994	92BR3-803	2408	1686	61	111	50	21.69	48.16	1
	92BR3-804(a)	2288	1885	61	114	53	20.07	43.17	1
	92BR3-805	1896	1999	61	114	53	16.63	35.77	1
	92BR3-806	2529	1961	61	110	49	22.99	51.61	1
	ORCA	**2348**	**1608**	**61**	**110**	**49**	**21.34**	**47.92**	**1**
	92IS 7315	2638	1638	61	109	48	24.20	54.96	1
	92IS 7333	1927	2019	61	104	43	18.53	44.81	1
	92IS 7343	1201	1871	61	109	48	11.02	25.02	1
	93SB 2809B	2993	1595	61	109	48	27.46	62.35	1
	MIDNIGHT	2160	2160	61	116	55	23.74	50.05	1
	Mean	2221							
	Pr>F	0.02							
	Lsd (0.05)	820							
	CV (%)	25.3							

Year	Entry	Yield (lb/a)	Seed/lb (NO.)	50% Bloom (Days)	Physiological Maturity (days)	Seed Fill Duration (days)	Yield Efficiency (lb/day)	Seed Fill Efficiency (lb/a/day)	Lodging
1995	USAZ-26	3405	1296	52	110	58	30.95	58.71	1
	USAZ-28	3735	1513	61	106	45	35.23	83.00	1
	USAZ-29	3933	1618	61	106	45	37.10	87.40	1
	USAZ-30	4178	1344	61	110	49	37.98	85.26	1
	USAZ-31	3539	1844	64	102	41	34.70	86.32	1
	ORCA	**4132**	**1507**	**61**	**102**	**41**	**40.51**	**100.78**	**1**
	UI-906	3508	2496	61	110	49	31.89	71.59	2
	Mean	3765							
	Pr>F	ns							
	Lsd (0.05)	704							
	CV (%)	12.6							
1996	**ORCA**	**3201**	**1668**	**62**	**100**	**38**	**32.01**	**84.24**	**1**
	USAZ-28	2717	1829	62	102	40	26.64	67.92	1
	UI 911	4018	2053	62	100	38	40.18	105.74	2
	Mean	3312							
	Pr>F	0.009							
	Lsd (0.05)	758							
	CV (%)	13.7							
2001	ORCA	2088	1397	57	117	60	17.85	34.80	27
	UI-911	2336	2257	46	118	72	19.80	32.44	24
	Midnight	2482	2533	57	118	61	21.03	40.69	31
	IBC-10-5-14	1952	2112	55	118	63	16.54	30.98	25

1993 and 1994 trials were in Rosa Research Farm.
1995 and 1996 trials were in Othello Research Farm.
2001 trial was in Vancouver Research Farm of WSU.

2001 DRY BEAN PERFORMANCE EVALUATION

An N. Hang and Virginia I. Prest
Washington State University - Prosser

Bean production in the U.S. does not consume domestically only, but does also play a very important role in export market. Bean acreage and production in Washington do not rank top in the nation, but it is a very important crop for its producers. Most of the bean grown in Washington is sold for seed with premium price. Bean testing and evaluation become very crucial to growers in Washington and the Pacific Northwest. WSU-IAREC is one of the 20 cooperators in North America participating in new and advanced bean lines testing for agronomic traits and economic potentials for the U.S. New potential bean lines were obtained from bean breeding programs of public and private institutions.

Materials and Methods

The trial was located at the Othello Research Farm, Irrigated Agricultural Research and Extension Center, Washington State University. The soil is a Shano silt loam soil and previously cropped with potato. Plots were pre-irrigated and a pre-plant herbicide application of 2 qt/a of Eptam and 1 qt/a of Sonalan was incorporated on May 14. Plots consisted of 4 rows (22" apart) of 25 ft long and the harvest area of 2 middle rows of 19 ft. Bean plots were planted on May 17 in randomized complete block design with 4 replications using cone seeder on a John Deere Flex planter to place seed at 3" apart. Cultivation and hand weeded as needed during the growing season. Furrow irrigation was applied as needed starting a month after seeding. Seedling vigor, 50% bloom, 50% maturity and percent of pods touching ground were recorded. Ten plants from each plot were pooled, air dried, weighed and threshed by a bundle thresher for computing harvest index and total biomass. At maturity, plots were blocked and two middle rows of each plot were cut, then threshed by a small plot thresher (one replication) and other replications were threshed by Hege, a small plot combine.

Results and Discussion

Seedling vigor was good for all lines except Hooter, a cranberry type bean; it was lower than average. Plants of all lines were shorter than normal. Some lines matured as early as 83 days after planting, e.g., cvs. Othello, LeBaron and ISB 5172. The latest maturity lines were yellow bean lines with 97 days after planting. Overall yield was low due to hard pan or soil compaction field. Several cultivations were used to loose the seed beds, but this procedure did not help bean growth and development, particularly the kidney varieties. Pinto group somewhat tolerated the adverse conditions. Yield varied from 514 to 3392 lb/a with the average of 2028 lb/a (Table 1).

Table 1. 2001 Advanced Variety Trial Data (Hang and Prest, WSU-Prosser)

ID	Line	MC	EV	DF	DM	PH	GH	LG	PC	BY	SY	HI	SW	AD
1	H9673-87	BK	3	57	89	32	2a	2	80	3389	1854	56	20	3
2	AC Mast	SW	4	50	95	40	2b	3	90	3461	1877	54	20	3
3	AC Trident	SW	4	56	92	44	2b	3	98	3314	1654	50	20	2
4	CPC 00125	SW	2	51	95	30	2a	3	85	3024	1496	50	33	4
5	Frigate	SW	3	50	96	59	2b	3	95	4430	2283	52	20	2
6	ISB 2598	SW	4	55	92	33	2a	2	95	3606	1942	54	22	3
7	93:207G	GN	2	50	87	40	2a	4	75	3857	2260	58	38	1
8	93:208G	GN	2	50	88	47	2b	4	60	3801	2252	59	40	2
9	98:163G	GN	3	50	91	46	2b	3	75	4293	2647	62	38	2
10	98:209G	GN	3	50	85	26	2a	3	50	4083	2571	63	37	3
11	ISB 5172	GN	3	52	83	33	2b	3	80	3156	1608	50	39	2
12	Matterhorn	GN	3	52	94	35	2a	2	80	4038	2455	60	37	2
13	UI 59	GN	3	51	90	30	2b	4	60	4730	2846	60	34	4
14	UI 465	GN	2	50	96	41	3b	5	50	4714	2668	56	34	3
15	US 1140	GN	3	49	88	25	2b	5	50	3710	2509	68	30	4
16	CDC Rosalee	PK	2	46	90	27	2a	3	80	2462	1253	52	26	5
17	93:219P	PT	2	50	88	38	2b	3	65	3927	2462	63	41	3
18	Bill Z	PT	2	50	94	43	2a	4	60	5255	3096	59	37	1
19	Buster	PT	3	52	90	45	2b	2	85	4824	2778	57	43	1
20	CO64342	PT	2	51	87	38	3a	4	70	5274	3158	60	38	1
21	CO75511	PT	3	52	94	30	2b	3	80	5117	3023	59	35	3
22	CDC	PT	3	48	85	32	2b	3	70	4851	2945	61	41	2
23	CDC Pintium	PT	3	48	86	29	2a	2	90	2659	1689	64	39	1
24	ISB 1145	PT	3	51	87	39	3b	5	50	5515	3392	62	39	1
25	Othello	PT	2	47	83	21	2b	2	80	4388	2858	66	36	2
26	UI 111	PT	3	49	85	28	2b	3	80	4685	2830	60	38	2
27	UI 114	PT	3	50	90	36	2b	5	50	5414	3255	60	40	2
28	UI 320	PT	3	49	85	34	2b	3	80	3445	2048	60	40	4
29	R93-365	RD	2	50	87	22	2a	1	95	2222	1159	52	33	2
30	CPC 99814	CR	3	48	85	22	1	1	85	1585	794	50	51	6
31	Hooter	CR	5	49	85	20	1	1	90	1521	865	57	47	2
32	H 9659-37-2	DK	3	51	85	31	2a	2	80	1726	930	54	47	2
33	H 9659-41-3	DK	3	55	87	37	2a	1	80	1887	914	48	38	2
34	Montcalm	DK	4	48	90	20	1	2	90	1611	640	40	42	2
35	Nichols	DK	4	48	85	19	1	1	95	1261	514	42	42	2
36	H 9659-21-1	LK	4	55	87	41	2b	2	90	1809	923	50	44	2
37	H 9659-23-1	LK	3	55	85	41	2a	2	80	2696	1073	41	40	3
38	CPC 00153	YL	3	51	94	22	1	2	85	2432	1400	59	35	6
39	CPC 00250	YL	4	52	97	20	1	1	85	2289	1280	56	35	5
40	CPC 01406	YL	3	51	97	21	1	1	85	2487	1352	55	36	5
41	B99204	BL	3	58	90	37	2a	1	95	.	2104	.	.	4
42	B95204	BL	3	57	90	34	2b	2	95	.	1802	.	19	.
43	B98306	BL	3	58	94	47	2b	3	95	.	2201	.	.	.
44	B00103	BL	4	59	96	37	2a	2	95	.	2149	.	.	.
45	B00136	BL	3	57	97	34	2a	2	95	.	2219	.	.	.
46	UI 911	BL	3	50	90	39	2b	2	92	3854	2019	53	20	.
47	N97774	SW	2	49	92	36	2a	3	95	.	2240	.	.	.
48	Roza	PK	2	49	87	49	2b	4	80	5033	3053	61	36	1
49	UI 259	RD	2	48	92	26	2b	3	90	4411	2476	57	35	2
50	LeBaron	RD	2	50	83	18	2a	1	90	2547	1610	63	36	2
	Mean		3	51		33				3514	2028	56	36	
	LSD (5%)		0.91	2.17		8.69				778.66	486.86	5.74	2.71	
	CV%		26.63	3.03		18.62				15.84	17.18	7.33	5.25	

MC: market class; EV: early vigor (1= excellent and 9= very poor); DF: days to bloom (from planting to 50% of plants set bloom); DM: days to maturity; PH: plant height in cm; GH: growth habit (1=determinate upright, 2a= indeterminate erect with short vine, 2b= indeterminate erect with long vine, 3= indeterminate prostrate); LG: lodging (1=erect and 9= all plants lay flat on the ground); PC: pod clearance (% of pods not touching ground or in contact with soil surface) taken at maturity; SY: seed yield in lb/a; HI= harvest index (%); SW= 100 seed wt in g; AD= appearance desirability from 1 to 9 where 1= excellent and 9=commercially unacceptable.

Table 2. Annual Weather Summary for WSU-Othello, 8 Mi E SE of Othello, WA

Lat:46.7 Lng:119.0 Elevation:1154

Dates Range From 1989-01-01 To 2001-12-31

Year	Max Air Tmp (F)	Min Air Tmp (F)	Avg Air Tmp (F)	Total Precip Inches	Total ETr Inches	Total ETo Inches	Wind Run Miles	Solar Rad Langley
1989	96.53	-4.54	49.91	4.58	54.11	50.53	52724	122148
1990	103.78	-9.58	51.04	5.29	55.95	54.02	57199	120665
1991	96.15	-1.66	50.2	7.21	51.88	48.99	48833	120459
1992	103.62	7.16	51.77	7.52	49.38	45.85	44977	116045
1993	96.58	-8.32	47.63	7.59	47.87	45.26	45672	116200
1994	100.76	5.72	51.62	8.8	55.17	53.27	45079	122699
1995	97.38	6.8	50.31	11.46	48.89	46.39	45562	117481
1996	99.75	-19.48	47.69	12.9	47.61	44.27	42867	123045
1997	95.97	5.36	49.86	21.74	45.18	42.64	43724	117327
1998	106.12	0.23	51.81	13.95	49.43	47.16	42435	120199
1999	97.75	23.22	50.71	7.75	52.05	50.22	48419	120480
2000	99.23	10.29	48.99	13.49	47.97	45.01	39685	122204
2001	99.23	13.51	50.12	11.05	50.48	47.1	41903	129459

Information provided by WSU Public Agricultural Weather System

EXPANDING WEB / E-MAIL ACCESS TO PNW DIRECT SEED CROPPING SYSTEMS TECHNOLOGY

PNW STEEP Extension Cropping Systems Team: Roger Veseth, WSU/UI Extension Conservation Tillage Specialist, Pullman/Moscow; Don Wysocki, OSU Extension Soil Scientist, Pendleton; Russ Karow, former OSU Extension Agronomist, Corvallis; Stephen Guy, UI Extension Crop Management Specialist, Moscow; Bill Schillinger, WSU Dryland Agronomist, Lind; Joe Yenish, WSU Extension Weed Scientist, Pullman; Greg Schwab, WSU Extension Soil Fertility Specialist, Pullman; John Burns, WSU Extension Agronomist, Pullman; Dennis Tonks, WSU Extension Dryland Cropping Systems Specialist, Davenport; Larry Robertson, UI Extension Crop Management Specialist, Aberdeen; and Brad Brown, UI Extension Crop Management Specialist, Parma.

The Internet and E-mail are rapidly becoming major communication and technology access tools for PNW Ag support personnel and growers. Most county offices of cooperative extension, conservation districts, USDA-NRCS, Ag service industries, and an increasing number of growers in the Pacific Northwest have Internet / E-mail access. A 2001 USDA National Agricultural Statistics Service study showed that an average of 58% of PNW growers have Internet / E-mail access, up dramatically from 18% in 1997 and 40% in 1999. Along with the growth in Internet and E-mail use, Northwest growers are increasingly moving towards direct seeding and more intensive cropping systems to improve production efficiency and profitability, cropland productivity, and environmental protection.

A PNW Web site and PNW Direct Seed List E-Mail Server (based at the Web site) are helping meet this expanding PNW demand for computer access to direct seed cropping systems technology. The Web site (http://pnwsteep.wsu.edu) "PNW Conservation Tillage Systems Technology Source" is part of an educational effort under the STEEP (Solutions To Environmental and Economic Problems) research and educational program on conservation tillage systems in Idaho, Oregon and Washington. It is also part of the educational efforts under the Columbia Plateau Wind Erosion / Air Quality Project and other related programs on conservation cropping systems technologies.

The Web site contains a wealth of technology resources and communication links. Averaging about 200 hits per day in 2001, the Web site is becoming an increasingly important information source. This Web site received a Certificate of Excellence in Web Pages in the 2000 American Society of Agronomy Educational Materials Awards Program.

Recent Web Site Redesign – An extensive redesign of the Web site is nearing completion….. though Web sites are never "done," because there are continual additions and revisions to keep them up to date. The Web site index has been reorganized at the top left of each linked page to help improve navigation within the site. Each sub-page now contains a listing of linked content items in "outline form" on the index, making it easy to view and go to specific components of the sub-pages.

Web Site Features / Updates
The following are brief descriptions of some of the major Web site's 14 major index features and recent design innovations.

PNW Conservation Tillage Update newsletters -- This newsletter provides a timely and effective technology transfer tool for STEEP and related research projects. Update issues highlight new research technologies, information resources and upcoming events related to direct seed cropping systems. The current mailing list is over 2,800, including primarily PNW producers (about 1,950), county Extension agents, Conservation Districts, NRCS staff, and Ag service industry, Ag media and other support personnel. Issues have also been posted on the Web site since 1995 (click on PNW Update Newsletter) to greatly expand access to the newsletters beyond the mailing list. E-mail / Web subscription options for the Update will be available soon.

PNW Conservation Tillage Handbook Series -- This PNW Extension Handbook currently containing 166 Handbook Series publications and they are now all available on the Web site (click on PNW Tillage Handbook). These publications summarize the latest research technologies from the PNW STEEP conservation tillage systems research program and other related PNW research efforts from the perspective of how NW growers can incorporate the new technologies into their management systems. Print copies of the new Handbook Series are distributed through the PNW Conservation Tillage Update newsletter.

Northwest Direct Seed Cropping Systems Conferences -- A Web site Conference page (click on Direct Seed Conferences) currently allows you to choose from the six Conference years (1998 through 2003). It is utilized extensively in publicizing the Conferences and providing access later to the proceedings and video information. In advance of the Conferences, the sponsorship / trade show prospectus, Conference pre-registration, and poster exhibition registration, sections now include registration templates that can be completed online, printed and mailed, or submitted directly via e-mail.

Direct Seed Resource Directories -- Two editions are currently available on the Web site (click on Resource Directories), and the third is in progress. They describe and provide access to information on more than 42 publications, videos, and other Web sites with additional information on direct seed cropping systems.

Northwest Direct Seed Grower Case Study Series -- A series of 16 full-color, 8-page publications in this PNW Extension bulletin series were completed from 1999 through 2001 with 3,000 print copies of each publication. The goal of the NW Direct Seed Case Study series was to facilitate grower-to-grower learning to enhance Northwest grower adaptation of direct seeding through increased access to the knowledge and experiences of these innovative growers. The Case Studies are all accessible on the PNW Web site (click on Grower Case Studies), as PDF files that can be viewed and printed as they look in published form. The first item on Case Study Series Web page is a "Series Overview," which briefly describes the format of the publications, and identifies the growers, farm locations, precipitation zones and common crop rotations.

PNW Direct Seed E-mail / Web List Server -- This Web-based List Server (click on Direct Seed List Server) offers an exciting communications link on new information resources, events, research results, technology innovations and experiences in the Inland Northwest. Begin with the brief overview and procedures on how to use the List Server. Note that for your e-mail privacy, the list server member list is not be accessible to List Server participants. Also, to prevent e-mail computer viruses from being sent to all participants, e-mails with attached files have now been blocked from the List Server. List Server messages are sent and received by e-mail and are also stored on the List Server Web site for later reference, and for access by those added to the List Server over time. When the List Server was established in late 1999, the initial address list included about 230 university and USDA-ARS researchers, extension specialists, county/area Ag extension educators, conservation districts, USDA-NRCS staff, PNW grower organizations, Ag industries representatives, and growers from across the dryland cropping areas of the Inland Northwest. From this initial base network, the List Server has been expanding to over 460 with interested growers and other Ag support personnel from across the region. More than 150 messages have been sent on the List Server. You can join the List Server from the Web site. You can also send your request to Roger Veseth, WSU / UI Extension Conservation Tillage Specialist and List Server administrator, 208-885-6386, e-mail (rveseth@uidaho.edu), and you will be sent an e-mail confirmation and more information on how to use the List Server.

PNW STEEP Annual Research Reports -- Annual reports for the PNW STEEP conservation tillage systems research program in Idaho, Oregon and Washington for 1998 through 2001 are accessible on the PNW Web site (click on STEEP Research Reports). Each report provides an annual summary of the results and accomplishments of about 20 STEEP projects. This Web section also includes a brief overview of the STEEP research program involving WSU, OSU, UI and USDA-ARS. It also features listings of new STEEP projects funded in 2001 and 2002, with project titles, researchers and project objectives.

NW Columbia Plateau Wind Erosion / Air Quality Project – Cropland wind erosion has long been a concern to growers in the low precipitation regions under dryland cropping and irrigation in the Pacific Northwest. This Web page (click on Wind Erosion / Air Quality) provides an overview of this comprehensive research and educational project involving a number of land grant universities and federal and state agencies in the region. The project includes research on defining and managing cropland sources of dust and particulate. A 72-page color publication titled "Farming with the Wind – Best Management Practices for Controlling Wind Erosion and Air Quality on Columbia Plateau Croplands" is being added to this Web page. The WSU Extension publication (MISC0208) provides a review of the best management practices for controlling agricultural wind erosion on the Columbia Plateau cropland, with highlights of research results from the Columbia Plateau Wind Erosion / Air Quality Project. For ease of computer access, this publication is being divided into separate PDF files by chapters that are linked to a Table of Contents.

PNW On-Farm Testing – This Web section (click on On-Farm Testing) contains PNW publications on on-farm testing methodologies and related resources to help provide growers and Ag advisers with practical approaches on how the more accurately evaluate the performance of new management strategies, equipment and products for conservation farming systems in the field. The results of over 250 on-farm trials in the region are available through several annual reports from a multi-year PNW STEEP on-farm testing project. A new, simple computer software program called "AGSTATS02" is nearing completion for statistical analysis of the on-farm trial results. This computer software, being developed through a STEEP project, should be available from this Web site later in 2002.

Web Resource Links -- A compilation of PNW, national and international Web sites with new technology resources for direct seed cropping systems is available on the Web site (click on Resource Links). Links are divided into four geographic categories: Pacific Northwest; Northern Great Plains/Canadian Prairie Provinces; U.S. – National; and International. Subdivision within each of those categories typically include: Research and Extension, Grower Organizations, and Ag Support Industries and Organizations. The current edition of Resource Links is Version 3 – February 2002. This listing is continually being expanded and updated. For everyone's benefit, Web site users are encouraged to submit links to other Web sites related to direct seed cropping systems.

Calendar of Events -- This Web page (click on Coming Events) provides an ongoing listing of conferences, field days, tours and other events related to conservation tillage systems in the Northwest, as well as applicable national and international events. Detailed descriptions and agendas of seasonal field days and tours related to direct seed cropping systems in the PNW are also posted.

Search Engine -- This new search engine (click on Search Our Site) allows extensive key-word searches of the entire Web site.

PNW Direct Seed Association -- There is a link to the home page of this Web site (click on Direct Seed Association) for the Web site of this new Pacific Northwest Direct Seed (grower) Association that is an increasingly important partner in research and educational efforts on direct seed cropping systems.

Retooling Agriculture PNW Publication -- This December 2001 PNW Extension bulletin (PNW553) is a full-color 42-page publication that describes the breadth and depth of public and private research and extension programs to facilitate the transition to direct-seed cropping in the dryland farming areas of the region. Free copies of the publication are available through PNW County Extension offices and you can also access it through this PNW Web site at (click on Retooling Agriculture at the bottom of the home page). To view and print the PDF file (as you see it in print), click on the colored line "Agriculture/Conservation Tillage Category on the above Web page that is linked to the WSU Extension Bulletin's Web site. Then scroll down though the publication list to the publication title "Retooling Agriculture …" and click on PDF file below the title.

Your Suggestions Are Welcome!

Let us know if you have any suggestions to help expand this Web site to better serve NW growers and Ag support personnel in developing successful direct seed cropping systems. Send them to Roger Veseth, e-mail (rveseth@uidaho.edu) or phone 208-885-6386.

PNW DIRECT SEED CASE STUDY SERIES AVAILABLE

Roger Veseth, WSU / UI Extension Conservation Tillage Specialist; **Ellen Mallory,** former WSU Case Study Project Coordinator; **Tim Fiez,** former WSU Extension Soils Specialist; **Dennis Roe,** USDA-NRCS Resource Conservationist; **Don Wysocki,** OSU Extension Soils Specialist

A series of 16 grower case study publications on direct seeding in the Inland Northwest was completed in 2001. These 8-page, full-color case studies were developed through grants from the Western SARE (Sustainable Agriculture, Research and Educations) and PNW STEEP (Solutions To Environmental and Economic Problems) programs. A total of 3,000 copies were printed of each Case Study. They are available free through Cooperative Extension in the PNW and are also accessible on the Internet.

Why Direct Seeding?

Direct seed farming systems offer the potential for environmental and economic win-win opportunities for growers and the public. There is a rapidly growing movement towards direct seeding and more intensive cropping systems across North America and around the world. These changes are being driven by a number of factors including: 1) the need to reduce production costs and improve profitability to compete in today's global market; 2) increased awareness of soil quality and productivity benefits of direct seeding and detriments of intensive tillage; 3) increased grower and public concern about soil loss by water and wind erosion, and their environmental impacts; 4) increased yield potential with improved water conservation, 5) advances in direct seed equipment and management technologies.

Grower adoption of direct seeding and other minimum tillage systems is increasing with the accelerated development of and grower access to new research technologies and experiences.
Many of our global competitors in the crop commodity markets are quickly making the transition to direct seed systems. Western Australia, Canadian Prairie Provinces, Argentina and Brazil have 25% to over 60% of their cropland in direct seeding -- over 60 million acres. Although only about 9% of PNW small grain production (~630,000 acres) was under direct seeding in 2000, it is increasing in response to this international competition in production efficiency and access to improved management technologies and equipment. In some Inland Northwest grain-producing counties, 20-50% of the small grain acreage is now under direct seeding.

Why a NW Direct Seed Case Study Series?

Many established direct seed growers in the Northwest say one of the keys to their success was having other direct seed growers share their experiences and knowledge with them as they developed their own systems. This series of 16 case studies provides the opportunity for a large number of grower and Ag support personnel -- anyone interested in direct seeding -- to learn from these growers' experiences across the Inland Northwest. The farms featured in this series are located across the range of rainfall zones of ID, OR and WA in the Inland NW region and illustrate a variety of equipment and cropping systems.

Each case study features a single farm operation and typically contains the following components: 1) How the growers started direct seeding, and lessons learned; 2) Description of their current direct seed system including: crops and rotation, residue management, weed, disease and insect control, fertility management and seeding strategies; 3) Description of the drills they are using; 4) Primary benefits and challenges of direct seeding; 5) Advice for growers new to direct seeding; and 6) Economic summary (when available).

Who Is Featured in the Case Studies?

The following is a listing of the PNW Extension Case Study Series on Direct Seeding in the Inland Northwest. They are grouped under low, intermediate and high precipitation zones.

<u>Low Rainfall (7- to 12-inches annual precipitation)</u>
PNW514 John Rea, Touchet, WA
PNW528 Ron Jirava, Ritzville, WA
PNW531 Frank Mader and Tim Rust, Echo, OR
PNW540 Bill Jepsen, Heppner, OR

<u>Intermediate Rainfall (13- to 19-inches annual precipitation)</u>
PNW515 John and Cory Aeschliman, Colfax, WA
PNW524 Jack, Mike and Jeremy Ensley, Colfax, WA
PNW523 Mike Sr. and Mike Jr. Thomas, Prescott, WA
PNW526 Tim, Kevin, and Kurt Melville, Enterprise, OR
PNW521 Paul Williams, Davenport, WA

<u>High Rainfall (20- to 26-inches annual precipitation)</u>
PNW516 Frank Lange, Garfield, WA
PNW527 Pat Barker and Steve Shoun, Dayton, WA
PNW522 Nathan and Steve Riggers, Nezperce, ID
PNW529 Wayne Jensen, Genesee, ID
PNW530 Art Schultheis, Colton, WA
PNW541 David Mosman, Craigmont, ID
PNW542 Russ Zenner, Genesee, ID

Publication Series Award -- This publication series was selected for a Certificate of Excellence in Extension Publications in the 2001 American Society of Agronomy Educational Materials Awards Program.

Accessing Print and Web Copies

Print copies are available free. They can be ordered through your local Cooperative Extension office or directly from the extension publication offices at the University of Idaho (208) 885-7982, Oregon State University (541) 737-2513 and Washington State University (800) 723-1763. The publications can also be accessed through the PNW Conservation Tillage Systems Web site (http://pnwsteep.wsu.edu) -- click on Direct Seed Case Studies for viewing, printing or downloading in PDF (Adobe Acrobat) format, just as they appear in printed form. The first item on Case Study Series Web page is a "Series Overview," which briefly describes the format of the publications, and identifies the growers, farm locations, precipitation zones and common crop rotations. A print copy of the Series Overview can be requested from Roger Veseth, WSU/UI Extension Conservation Tillage Specialist, P.S.E.S. Dept., University of Idaho, Moscow, ID 83844-2339, phone 208-885-6386, Fax 885-7760, or e-mail <rveseth@uiaho.edu>.

NW DIRECT SEED CONFERENCES EXPAND TECHNOLOGY ACCESS

Roger Veseth, WSU / UI Extension Conservation Tillage Specialist, Pullman / Moscow

Direct seed cropping systems can effectively control PNW cropland soil erosion and associated water and air quality problems, and improve soil quality and productivity, while potentially increasing grower profitability and competitiveness. However, grower access to the latest technologies and experiences is critical to the successful development of these new farming systems. From 1977 through 1997, PNW Conservation Tillage Conferences and STEEP Annual Reviews of conservation farming research helped facilitate technology access, but audiences typically were only about 150-300. A new approach was needed to provide more PNW growers and Ag advisers with first-hand access to new management technologies and experiences.

New Conference Series – The first Northwest Direct Seed Cropping Systems Conference was initiated in Pasco, WA, in 1998 – with a remarkable attendance of just over 900 growers and ag support personnel. It was organized through the PNW STEEP program in conjunction with a number of ag support companies and organizations. STEEP (Solutions To Environmental and Economic Problems) is a research and educations program on direct seed / conservation tillage systems through WSU, OSU, UI and USDA-ARS. The five annual conferences from 1998 through 2002 had an average annual attendance of over 820 (ranging from 620 to 980). Over 99% of the 1998-2002 conference evaluation respondents felt that the conferences would help increase the success and adaptation of direct seed systems by Northwest growers.

New Conference Innovations – A number of new, innovative features and organizational strategies dramatically improved the potential to attract much larger grower audiences and improve technology access. These have included: • Inviting international and out-of-state national speakers; • Increasing the number of Northwest grower speakers from 2-3 to 6-16; • Publishing in-depth Proceedings distributed at the Conferences; • Producing videos of the conferences and making them available for loan / sale; • Involving more than 12 agricultural companies and groups as financial co-sponsors to cover additional costs of invited speakers, proceedings, videos and expanded promotion (no financial co-sponsors in previous conferences); • Adding a new commercial trade show on direct seed systems (1999, 2000, 2003) and combining with an existing trade show—the Spokane Ag Expo (2001, 2002); • Creating a conference Web site (http://pnwsteep.wsu.edu/directseed) for increased publicity and later access to the Proceedings, videos and other resources; • Involving 14 PNW grower and conservation district associations, and other groups as cooperators in helping develop and promote the conferences—the PNW Direct Seed Association became a co-organizer beginning in 2001; and • Utilizing extensive direct mailing of conference brochures through grower organization mailing lists, e-mail announcements through those grower and industry groups, and expanded use of paid ag media advertisements

Conference Highlights

The 1998 Northwest Direct Seed Cropping Systems Conference in Pasco, WA featured 48 speakers including: 16 growers from the PNW, Australia, and Canada; 11 ag industry representatives; and 13 researchers from the PNW, South Dakota and Indiana.

The 1999 Conference and (New) Trade Show in Spokane, WA, featured 37 speakers, including 14 researchers and 7 industry representatives and 16 growers from across the Pacific Northwest, Northern Great Plains, Canada, Argentina, and Brazil. On-line registration for conference co-sponsorships, conference pre-registration and poster exhibition registration was initiated. The commercial Direct Seed Trade Show was added at the request of growers.

The 2000 Conference and Trade Show in Pendleton, OR, featured 26 speakers including researchers, industry and agency representatives, and growers from across the Pacific Northwest, Canada and Australia.

The 2001 Conference in Spokane took another step to further expand NW grower participation. It was held in conjunction with the Spokane Ag Expo—the largest Inland Northwest ag show with an audience of over 6,000—and the PNW Farm Forum and seminar series, with conference registration including entrance into Ag Expo and PNW Farm Forum. The new PNW Direct Seed Association was also involved as a co-organizer beginning with this conference. The program featured 27 speakers including 14 growers from Idaho, Oregon, Washington, Montana, North Dakota, Chile, Germany, and New South Wales, Australia, as well as researchers and Ag industry representatives from the Pacific Northwest, Canada and Colorado.

The 2002 Conference in Spokane, WA, was again held in conjunction with Spokane Ag Expo and PNW Farm Forum, and conference registration included entrance into these two events. The program featured 24 speakers, including 10 growers, from Idaho, Oregon, Washington, and the Canadian provinces of Alberta and Saskatchewan.

2003 NW Direct Seed Cropping Systems Conference Plans

The Sixth Northwest Direct Seed Cropping Systems Conference and Trade Show is scheduled for January 8-10, 2003, at the West Coast Hotel (formerly Doubletree), in Pasco, WA. The conference is again being organized by the PNW STEEP research and education program, and the PNW Direct Seed Association, with a number of ag support companies as co-sponsors, and developed in cooperation with about 14 other PNW grower and ag support organizations.

The program will feature about 26 growers, researchers and ag industry representatives from Idaho, Oregon, Washington, South Dakota, New Zealand and Canada. Preliminary program topics include: • NW grower experiences with direct seed systems across precipitation zones; • Pros and cons of lower versus higher disturbance direct seed systems; • Economic strategies for managing risk in the transition to direct seed systems; • Effects of residue management strategies on direct seed drill performance; • "Stacked rotations" and other strategies for minimizing weed and disease problems in direct seeding; • Weed management strategies for Clearfield wheat systems across PNW precipitation zones; • Evaluation of glyphosate formulations for burndown in direct seed systems; • Alternatives to glyphosate as part of a resistance management strategy in direct seed systems; and • New innovations in direct seed equipment designs.

The conference Web site (http://pnwsteep.wsu.edu/directseed) will provide continued updates on the conference program, hotel reservations, registration and all other conference topics. You can also contact the Conference Office at 509-547-5538 or Fax 509-547-5563.

CUNNINGHAM AGRONOMY FARM—SERVING NW AGRICULTURE THROUGH DIRECT-SEED AND PRECISION-AGRICULTURE TECHNOLOGIES

R. James Cook, Ryan Davis, Bruce Frazier, Rob Gallagher, Dave Huggins, Tim Paulitz, Greg Schwab, Joe Yenish, and Doug Young

In 1998, a team of Washington State University and USDA-ARS scientists and engineers launched a long-term direct-seed and precision-agriculture cropping systems study on 140 acres of the WSU-owned Cunningham Agronomy Farm located about 7 miles NE of Pullman, WA. The team consists of faculty, graduate students and technicians from the Departments of Crop and Soil Sciences, Plant Pathology, Agricultural Economics, Biosystems Engineering, Center for Precision Agriculture Systems, Program in Statistics, USDA Agricultural Research Service in the CAHE and Department of Geology. The work on this farm is intended to help growers and the supporting agribusinesses and state agencies adjust to and profit from some of the greatest technological changes for Northwest agriculture since the introduction of mechanization early in the 20th century. The Washington Wheat Commission provided $120,000 as the start up budget for the first three years—1998/99, 1999/00, and 2000/01. STEEP funding in the amount of $137,000 will become available starting in late 2002. Other funds have been provided from the Harry E. Goldsworthy Wheat Research Fund, the WSU Center for Precision Agriculture, the Cook Endowed Chair in Wheat Research, and the Washington Wheat Foundation. More than $10,000 was contributed in 2001 through in-kind donations of seed and chemicals by 13 benefactors representing the agribusiness community and listed later in this report.

The broad goals of the work on this agronomy farm 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;
- Develop the agronomics for alternative crops as components of more diverse crop rotations to better manage weeds, diseases, soil fertility and crop residue while maintaining a strong emphasis on wheat and a balance between fall- and spring-sown crops;
- Obtain base data and understanding needed to model and predict carbon sequestration over a Palouse landscape in response to different crop rotations; and
- 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-farming technology in this region.

Over the past 3 years, from early 1998 to early 2001, the team has converted this 140-acre farm into what promises to be scientifically the most comprehensive direct-seed and precision agriculture cropping systems study in the United States if not the world. A 92-acre portion of this 140-acre field is probably the most intensively mapped, sampled, and characterized 92 acres of land anywhere in the state of Washington if not the entire Northwest. A 12-member advisory committee consisting of growers, agribusiness representatives, and government regulatory agencies has met twice in 2000 and 2001 to review and give guidance to the work. The first field day was held in June, 2001. The next field day will not be until 2003, but anyone wishing to know more about the work on this farm can contact any member of the team.

Yields and grain protein were determined by hand harvesting at 369 GPS-referenced sites representing 92 acres of hard red spring wheat (WPB 926) in 1999 and spring barley (Baronesse) in the same 92 acres in 2000 (see Figures 1-4). For both crops, we found all combinations of high yield and high grain protein, low yield and high grain protein, high yield and low grain protein, and low yield and low grain protein, all in the same field. These yield and grain protein maps are also beginning to reveal some patterns of consistency, indicating that areas of low and high yields tend to occur in the same general locations within the field each year. Some of this variable yield can be explained by depth of the soil to an Argillic clay layer, which varies from 3-4 feet deep in some places and greater than 5 feet deep in other places. Maps are also available and updated seasonally for other factors that affect yield and/or grain protein, including soil water and nitrogen in the profile, density and location of wild oats, other weeds, and the major wheat and barley root pathogens.

Following the 1998/1999 and 1999/2000 crop years, when the entire farm was planted to single crops, the 92-A intensively mapped portion of the farm was divided into three fields of about 30 acres each for initiation of six different nonreplicated 3-year crop rotations (see Figure 5). Each of the six 3-year crop rotations consist of winter wheat-altcrop-spring wheat. The alternative crops are winter and spring barley, winter and spring pea and winter and spring Canola. These six crops were established in approximately 5-A strips within one of the three 30-A fields in an orientation roughly perpendicular to field variations in slope, aspect and soil so as to capture the main spatial variability contained in the field. Starting in the fall of 2001, winter wheat was planted after the spring wheat, and the three fall-sown alternative crops were planted as 5-A strips directly into the 2001 winter wheat stubble. In the spring of 2002, spring wheat was planted uniformly over the six strips of 2001 alternative crops and the three alternative spring crops were planted alongside their fall-sown counterparts as 5-A strips in the 2001 winter wheat stubble.

As the crop rotation progresses, uniform plantings of spring wheat (30 acres) will always follow the six alternative crops, winter wheat will always follow spring wheat, and the alternative crops will always be planted into the winter wheat stubble. In this way, each rotation is two-thirds wheat, the two rotations with winter and spring barley will be continuous cereals, and two of the four rotations with broadleaf crops will focus on performance of fall-sown Canola and peas. The rotation with spring Canola will use Round-up Ready Canola, which will provide experience with an herbicide-tolerant crop. In addition, small-scale replicated plots of varieties of most of the rotation crops are included within the bulk fields of the different crops to gain experience with locally available varieties in direct-seed systems.

Most 3-year crop rotations in the Palouse region that use a broadleaf crop also then follow the broadleaf with winter wheat and then the spring cereal, either spring barley or spring wheat. The rationale for reversing this sequence, i.e., for following the alternative crops with spring wheat and then winter wheat is as follows.

- Planting winter wheat into spring wheat stubble should be easier than planting spring wheat into the typically heavier winter wheat stubble.

- Because winter wheat is harvested earlier than spring wheat, potentially this could permit earlier planting of the winter Canola.

- Wild oats should be easier to control where spring wheat follows an alternative crop rather than winter wheat, especially if the alternative crop is Round-up Ready Canola.

- For rotations that include barley, planting spring wheat rather than winter wheat after the barley will avoid the problem of carryover barley in the winter wheat.

- The chance for early warm-up of soil needed for spring wheat will be greater for spring wheat seeded into stubble of a broadleaf crop than into stubble of winter wheat.

On the other hand, with this sequence, the class of winter wheat will need to be the same as the class of spring wheat for years of heavy carryover volunteer spring wheat in the winter wheat. Moreover, the challenge of fall-planting into fresh winter wheat stubble still exists and must be met in the cases of the fall-sown barley, peas, and Canola.

In addition to this large-scale crop rotation study, or in some cases as part of the crop rotation study, work is underway on crop modeling, fall- versus spring-applied nitrogen for achieving high grain protein, straw management alternatives to burning, monitoring water quality, weed management and growth modeling, mapping the distribution of soilborne pathogens with a DNA test, and experimentation with direct-seeded corn.

In-kind support from area agribusinesses and other interest groups

We very much appreciate the responses provided as in-kind services from the following area agribusinesses: BASF, Bayer, Columbia Grain, DuPont, Farm & Home Supply, Great Plains, McGregor Co., McKay Seeds, Monsanto Co., Pioneer Seeds, Syngenta, Western Plant Breeders, and Whitman County Grain Growers.

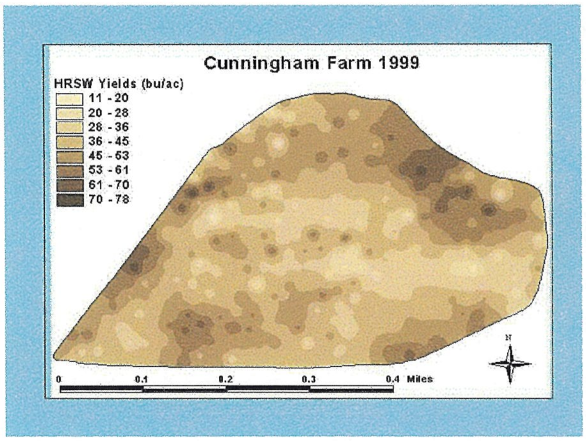


Fig. 1. Field variability of hard red spring wheat (WB 926R) yield across 92 acres.

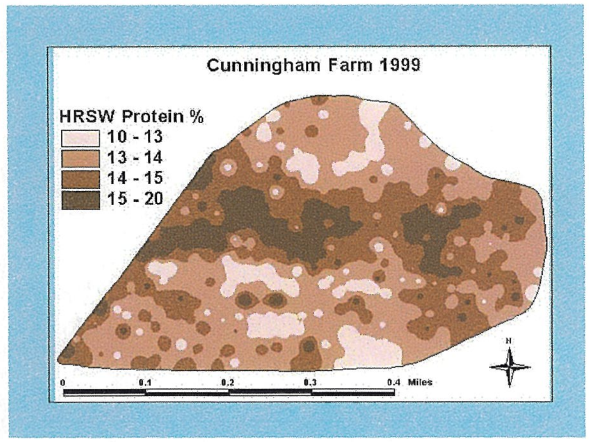


Fig. 2. Hard red spring wheat grain protein variability across 92 acres (1999).

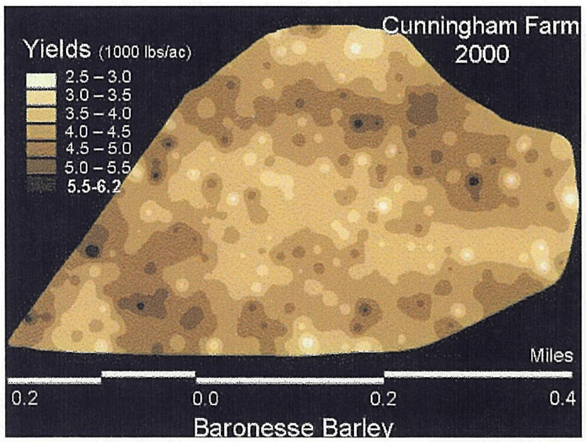


Fig. 3. Yield variability of spring barley (Baronesse) across 92 acres (2000).

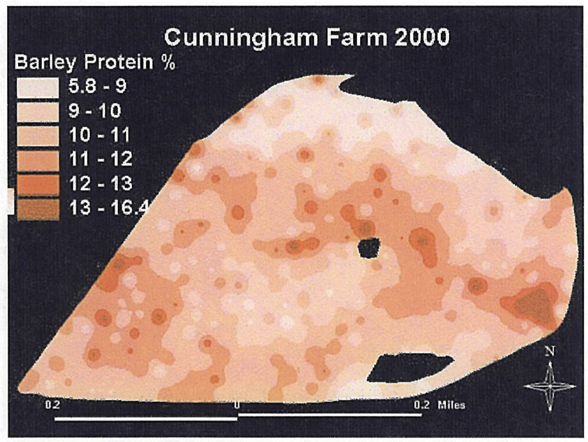


Fig. 4. Field variability of spring barley grain protein (2000).

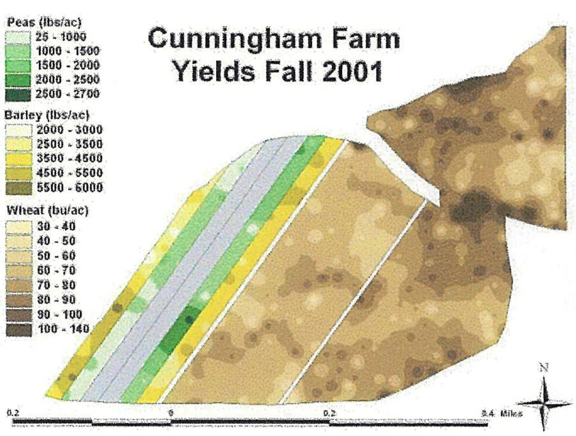


Fig. 5. Grain yield of six alternative crop strips (from west portion of field: winter barley, winter pea, winter canola, spring canola, spring pea, spring barley), hard red spring wheat (Hank) in center of field, and winter wheat (Madsen) in western portion of field (2001).

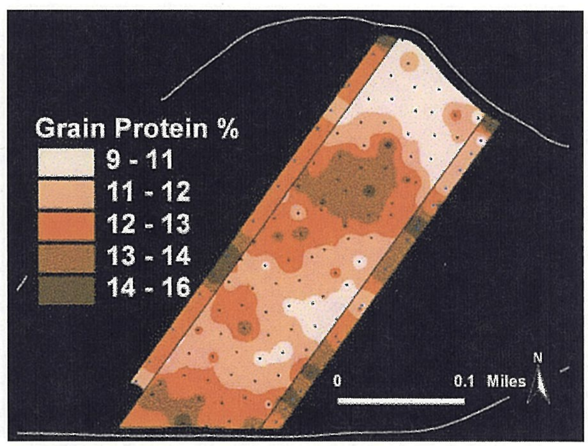


Fig. 6. Field variability of hard red spring wheat grain protein and effects of split fall-spring (two outside strips of field) versus all spring applications of N fertilizer.

OVERVIEW OF THE SPOKANE COUNTY AND NORTHWEST CROPS DIRECT SEEDING PROJECTS

by Diana Roberts, WSU Cooperative Extension

The Spokane County Direct Seeding Project and the Northwest Crops Project are related to the Wilke Project as they are all grower-driven, all trials are large-scale and utilize farm-size equipment, and members of the WSU Cooperative Extension Ag Horizons team coordinate them. The Ag Horizons team is committed to learning alongside farmers and including them as equal partners in developing research and demonstration projects. Dennis Tonks now leads the Wilke Project, which completed its fourth season in 2001. It is centered at the WSU Wilke Farm at Davenport, with a focus on the intermediate rainfall area (12 to 17 inches) of Lincoln and Spokane counties. Team members Dennis Roe (NRCS) and Roger Veseth worked with Whitman and Garfield county growers to design the Northwest Crops Project, which has also completed its fourth season. I worked with a group of Spokane County growers and the Spokane County Conservation District to determine a direction for direct seeding in that area.

In 2000, we won a 3-yr grant from the USDA-SARE (Sustainable Agriculture Research and Education) program to fund the Spokane County Direct Seeding Project and the Northwest Crops Project, and to support extension of all three projects. Last March we hired Dennis Pittmann, who farmed at Oakesdale for 33 years, as technician for the work in Spokane and Whitman counties; he is based in Colfax. The NRCS, Spokane County Conservation District, Palouse-Rock Lake Conservation District, Palouse Conservation District, Whitman Conservation District, and Pine Creek Conservation District are partners with Cooperative Extension in these two projects.

The farmer cooperators in the Northwest Crops Project are comparing a four-year direct seed rotation; winter wheat – warm season grass (corn) – broadleaf – spring wheat with a three-year rotation; winter wheat – spring barley – chem. fallow. The 4-yr rotation includes a warm season grass to provide different windows for weed management and a broadleaf to help break disease cycles. The trials are set up in on-farm testing strips with each plot/crop being at least 30 ft by 500 to 700 ft. The cooperators are Tracy Ericksen (St. John), Steve Swannack (Lamont), Leroy Druffel (Colton), Dave and Paul Ruark (Pomeroy), John and Cory Aeschliman (Colfax), Steve and Dan Moore (Dusty), and Randy Repp (Dusty). They selected a similar soil type for each site, and each cooperator grows one replication of the rotation on his farm, except for Steve Swannack who has two replications.

We are in the process of analyzing the data collected so far, but the project will run at least through 2003, and then we will publish yield and economic results. Following are observations from the plots.

- The 4-yr rotation keeps the field in cover (crop or residue) for the entire year. Due to the chem. fallow, the 3-yr rotation maintains less residue.
- Corn shows potential as a rotation crop in the intermediate rainfall area where the weather is warm enough for timely maturity.
    - Cooperators have seeded corn successfully (rather than barley) into heavy residue.
    - Corn provides opportunity for broad-spectrum weed management.
    - Corn yields are sometimes comparable to barley.
- Earthworm activity has increased at most sites.

- Cooperators have noticed improved soil tilth in their plots.
- The cooperators have not used field burning in these plots, but they have been able to seed successfully into heavy residue in the 4-yr rotation (where they use corn rather than the barley that follows winter wheat in the 3-yr rotation).

Spokane County is somewhat unique in the region; it's part of the Palouse, yet colder than the Pullman area and with a climate suitable for Kentucky bluegrass production. Growers in the annual cropping zone (18 to 22 inches precipitation) have identified residue management as a primary challenge to successfully adopting direct seeding. Seeding through heavy residue can be tough in the fall, and especially in the spring when thick winter wheat straw tends to keep the soil cold and wet.

The Spokane County growers participating in the project identified specific questions they wanted answered, and designed their own trials to solve them. Not surprisingly, most of the questions relate to residue management.

1. Larry Tee (Latah) is comparing different stubble heights for fall direct seeding, working on the theory that one should not have seeding problems if the standing stubble is shorter than one's drill row width.
2. David Ostheller (Fairfield) has four residue management treatments on winter wheat stubble to prepare for spring direct seeding: 1) mowing, 2) fall harrowing, 3) fall disk-rip plus spring harrowing, and 4) standing stubble.
3. Glenn and Bryan Dobbins (Four Lakes) are testing a commercial residue digester called Biocat™. The product is not a microbial solution, but a nutrient mix that stimulates the growth of microbes found naturally in the soil. They apply Biocat to winter wheat residue following harvest, and look at how it affects stand establishment and yield of direct seeded fall and spring crops.
4. Randy and Jeff Emtman (Rockford) have been successful at taking out bluegrass stands by direct seeding oats into them. However, they haven't always been able to achieve an acceptable test weight on the oats, so they are looking at a fall fertilizer regime that should enable them to do this while allowing them flexibility to keep the grass stand in if it looks good in the spring.
5. Paul and Jake Gross (Deep Creek) are testing a late fall rotary subsoil treatment for its potential to improve water infiltration into the soil and boost crop yields under direct seeding.

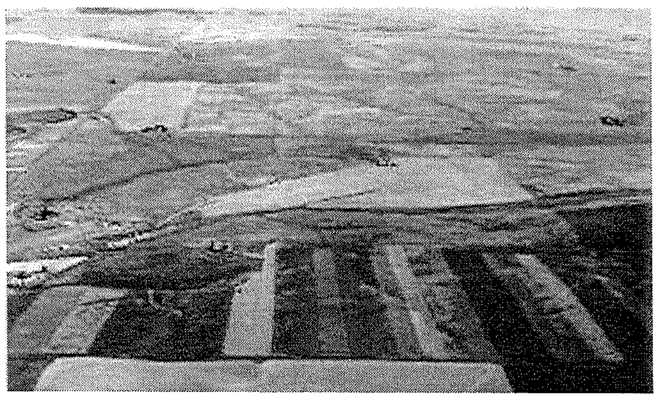
The growers conducted their trials in replicated on-farm testing strips in 2001. We have analyzed the results, but consider them preliminary as they are from one season only. You may obtain a copy of the 2001 report from Diana Roberts, or go to http://www.spokane-county.wsu.edu/ and click on the farming icon then the direct seeding link. Each grower will repeat the trial for two more years so we can develop a good picture of how the treatments work over different seasons. We will then publish yields and economic data.

Extension is an important part of all three projects, and we host workshops and field tours so that growers can learn from the trials. The Spokane Project tour will be June 25, 2002, and the Wilke Field Day is June 26. Lincoln and Spokane growers have also formed direct seed discussion groups. You may obtain annual reports of the projects or details on all these events from the above website or from the project contacts: Diana Roberts (phone 509-477-2167, e-mail robertsd@wsu.edu); Dennis Pittmann (phone 509-397-4636 ext 115, e-mail pittmann@wsu.edu); Dennis Roe (phone 509-397-4636 ext 117, e-mail rdroe@coopext.cahe.wsu.edu); and for the Wilke Project, Dennis Tonks (phone 509-725-4171, e-mail dtonks@wsu.edu). And if you're confused by all those Dennis's, imagine how I feel when the phone rings and the caller says, "Hello, this is Dennis."

THE WILKE DIRECT SEED PROJECT

Dennis Tonks, Extension Dryland Cropping Systems Specialist
Darla Rugel, Ag. Research Technician
WSU Cooperative Extension
Davenport, WA
For the Ag Horizons Team

The Wilke Direct Seed Project was initiated in 1997 after a group of growers and extension personnel interesting in adopting direct seeding systems visited the Dakota Lakes Research Station near Pierre, South Dakota. In 1998, two rotations were initiated on the WSU Wilke Farm near Davenport and on five cooperator farms within a 30-mile radius of Davenport.



A large portion of the Wilke Farm Research Farm was placed into replicated strips or plots representing a 3- or 4-year rotation. The 3-year rotation is an extension of the traditional winter wheat – spring cereal – fallow rotation commonly practiced in the Lincoln County area. This rotation includes winter wheat – spring cereal – broadleaf crop. The 4-year rotation found to be successful in the Great Plains region is a spring wheat – winter wheat – warm season grass – broadleaf sequence. In addition, five grower cooperators repeated either the 3- or 4-year rotation on their farms. Plot sizes ranged from 8 to 10 acres on the Wilke Farm to 25 to 100 + acres on the cooperator fields. Each part of the rotation sequence was present each year. Within a rotation, growers were allowed to choose individual crops they believed would suit their farm and market opportunities. All field operations were performed using grower equipment. The study was repeated for four years. Agronomic and economic data were collected from all sites. Parameters included stand establishment, weeds, insects, diseases, crop yield and residue, soil organic matter, water infiltration, and earthworm populations. Input costs also were monitored to allow economic return data to be calculated.

2001 was the fourth year of the project and each field has been through at least one crop cycle. While much of the data are still being analyzed at the time of this writing, there are some conclusions and observations that can be drawn.

Weed Management
Weed management appears to be one of the most limiting factors in successful adoption of direct seeding. Over the four years of the project, weed control was one of the most expensive inputs of the project. Wild oats were the most troublesome weed especially in some of the alternative crops. The lack of registered herbicides for wild oat control is a major concern for diversified crop production. It appears that some perennial weeds, such as Canada thistle, may be more of a problem in direct seeded fields.

Alternative Crops
The PNW has had a long history of wheat production and research. There is a lot left to learn about the production of alternative crops. Alternative crops that have been grown in the project are canola, yellow mustard, peas, flax, sunflowers, peas, safflower buckwheat, proso millet, and corn. Canola may have the best promise for an alternative crop in the intermediate rainfall area. There are adequate herbicides available for control of wild oats; however, broadleaf weeds can be quite problematic. The use of herbicide resistant varieties could help the situation. Peas may have a fit in some areas; again there are registered herbicides for wild oat control. Yellow mustard may also have a good fit in rotations, but there are no registered postemergence herbicides for wild oat control. Fax, sunflowers, and safflower have been grown with mixed results. In 1998, safflower was grown on the Wilke Farm and with the lack of wild oat control, the population exploded drastically. Proso millet seed production was low for all years grown in the study. This may be due to unadapted varieties, a climate not well suited for millet production. Even though the crop was planted late (late May or early June), wild oats continued to be problematic in millet. Proso millet did, however, create a lot of crop residue. It may be better suited as a forage crop in this climate. One cooperator who grew corn and Sudangrass harvested them for forage to deal with wild oat problems. Several of the alternative crops were not harvested due to frost, shattering, or weather. The lack of ready markets for alternative crops is also a limiting factor in adoption.

Residue
Crop residue varied depending on crop, year and location. Cereal crops produced the most crop residue while broadleaf crops produced the least amount of residue. In 2000, crop residue was lower than the other years due to dry growing conditions.

Soil Quality
Although analysis of soil quality parameters is still being evaluated, it appears that soil organic matter has increased over the four years of the study. Water infiltration has also increased over the four-year time period. Soil erosion by water was only observed after rains on frozen soils and there was no wind erosion observed. As of yet, no earthworms have been found on the Wilke Farm or any of the cooperator fields. This work is continuing.

Although the formal cycle for the Wilke project has concluded, we are continuing with the project on a more limited data collection basis. This year we have eliminated millet from the rotation, replacing it with barley. Local growers have a strong interest in the project with 80 to 120 producers attending the annual field day. Part of what has made the project successful is the grassroots approach to the project and support from the cooperators and local growers.

LONG-TERM DRYLAND CROPPING SYSTEMS RESEARCH AT LIND: THE NEXT SIX YEARS

Bill Schillinger, Harry Schafer, and Bruce Sauer
Department of Crop and Soil Sciences, Washington State University

Annual cropping systems research using direct seeding has been ongoing at the Lind Dryland Research Station since 1998 (see the article entitled "Dryland direct-seed annual cropping systems research at Lind: the first four years" in this publication). Annual spring cropping was not economically competitive with winter wheat – summer fallow at Lind from 1998 to 2001.

A committee of growers and researchers met at the Lind Station in February 2002 to discuss and design the next phase of the experiment. The recommendation of the committee was to keep continuous annual soft white spring wheat (the most competitive annual spring rotation) and add several new treatments. Beginning in 2002, the crop rotations for the next six years are the following.

1. Continuous annual soft white spring wheat.
2. Continuous annual hard red spring wheat.
3. Continuous annual hard white spring wheat.
4. Winter wheat – summer fallow (tillage).
5. Winter wheat – spring wheat – spring wheat.
6. Winter wheat – spring wheat – chemical summer fallow.
7. Winter wheat – spring wheat – summer fallow (tillage).

Each phase of all treatments will appear every year. The experimental design is a randomized complete block with four replications, thus a total of 56 plots. Individual plots in the original experiment were 45 ft X 500 ft, whereas plot length in the second phase is 225 ft with a 50-ft alley in the middle. All no-till plots are 15 ft wide, and tillage plots are 30 ft wide. Thus, all seven of the new treatments fit within the area of the original experiment. Grain harvest will be with a plot combine, then the entire experiment area will be "blanket harvested" with a commercial-scale combine to uniformly spread straw and chaff. Tillage (in treatments 4 and 7 above) will be with a wide-blade undercutter sweep, both to control Russian thistle after harvest (if needed) and for primary spring tillage, followed by two rodweedings (i.e., minimum tillage). All other treatments will be direct seeded and fertilized in one pass with a Cross-slot drill.

We are excited about this new experiment and hope that it will provide comprehensive information to growers in low-precipitation regions of the inland Pacific Northwest. This project will be shown and discussed at future Lind Field Days.

Acknowledgments
The authors thank the following growers and scientists for their input on the design of this project: Bob Bandy, Wilbur; Jim Cook, Pullman; Rob Dewald, Ritzville; Gary Galbreath, Ritzville; Ron Jirava, Ritzville; Tim Herdricks, Wilbur; Randy Kulm, Lind; Bob Papendick, Pullman; John Rea, Touchet; Lenard Roth, Lind; Mark Sheffels, Wilbur; Jerry Snyder, Ritzville; Linda Tate, Almira; Tony Viebrock, Waterville; Roger Veseth, Moscow; Ed Deife, Odessa; Lon Welch, Connell; Don Wellsandt, Ritzville; and Doug Young, Pullman.

DRYLAND DIRECT-SEED ANNUAL CROPPING SYSTEMS AT LIND: THE FIRST FOUR YEARS

William Schillinger, Harry Schafer, Bruce Sauer, Ann Kennedy, and Keith Saxton
Department of Crop and Soil Sciences and USDA-ARS, Washington State University

A long-term study was initiated in 1998 to evaluate annual direct-seed cropping at the Washington State University Dryland Research Station at Lind. Cropping systems were (i) a 4-year safflower/oats/spring wheat/spring wheat rotation, (ii) a 2-year winter wheat/spring wheat rotation, and (iii) continuous spring wheat. Individual plots were 500 ft long and all crops were sown with the Cross-slot drill. Measurements obtained each year are soil water use by each crop, weed populations, and grain yield. Safflower provided fairly stable yields (avg. 799 lbs/a), but depleted soil water to a much greater extent than did spring wheat (data not shown). In 2000, recrop winter wheat yielded 40 bu/a compared to 24 bu/a for continuous annual spring wheat.

The 2001 crop year was one of drought that severely affected spring-sown crops in all low-rainfall dryland regions in the inland Pacific Northwest. Grain yield in continuous spring wheat plots was 15 bu/a (Table 1). Recrop winter wheat was hit by a late May frost while in the flowering stage of development and yielded only 13 bu/a (Table 1). Over the past four years (1998-2001) at Lind, average grain yield of continuous direct-seeded soft white spring wheat is 22 bu./a compared to a station average 44 bu./a for soft white winter wheat after fallow (Table 2). Average annual precipitation for the past four crop years at Lind was 9.24 inches compared to the long-term (80-year) average of 9.61 inches.

Table 1. Crop yields in three direct-seeded rotations at Lind: a 4-year safflower/oats/spring wheat/spring wheat rotation; a 2-year winter wheat/spring wheat rotation and; continuous spring wheat.

	Units	1998[x]	1999	2000	2001	4-yr avg.
1. Four-year rotation						
Safflower	lb/a	890	775	1005	525	799
Oats	ton/a	1.23	0.46	0.78	0.09	0.64
1st year wheat	bu/a	---	18	21b[y]	8b	---
2nd year wheat	bu/a	---	---	22b	9b	---
2. Two-year rotation[z]						
Winter wheat	bu/a	---	---	40a	13a	---
Spring wheat	bu/a	---	---	24b	9b	---
3. Continuous wheat	bu/a	28	21	24b	15a	22

x All crops were sown into spring barley stubble in 1998, which was the first year of the study.

y Within column means followed by a different letter indicate significant wheat grain yield differences at the 5% probability level.

z The winter wheat–spring wheat rotation was included beginning in the 2000 crop year.

Table 2. Grain yield comparison of annual direct-seeded soft white spring wheat versus winter wheat after summer fallow during four years at Lind, WA.[x]

Year	Annual Spring Wheat	Winter Wheat After Fallow	Yield Ratio SW/WW	Crop Year Precip. (inches)
1998	28	58	48%	9.45
1999	21	40	52%	9.86
2000	24	48	50%	9.34
2001	15	29	55%	8.30
4-yr avg	22	44	50%	9.24

x Spring wheat yields are from the replicated long-term spring cropping research project whereas winter wheat yields are the average for similarly deep soils at the WSU Dryland Research Station.

As one cycle of the 4-year rotation was completed in 2001, an advisory meeting of growers and scientists will be held in February 2002 to decide future crop rotations for this experiment. See the article entitled "Long-term dryland cropping systems research at Lind: The next six years" in this publication.

LONG-TERM DIRECT SEED ALTERNATIVE CROPPING SYSTEMS RESEARCH AT THE RON JIRAVA FARM: YEAR 5

Bill Schillinger, Ron Jirava, Harry Schafer, Jim Cook, Doug Young, Ann Kennedy, and Steve Schofstoll

Summary of Research Findings

The 2001 crop year was one of extreme drought that severely affected spring-sown crops in all low-rainfall dryland regions in the inland Pacific Northwest. Grain yield in continuous spring wheat plots was 14 bu/a in 2001 compared to the previous 4-year average of 44 bu/a. After consulting with a grower-scientist advisory committee, two new 4-year rotations were added to the study for years 2001-2004 (Table 1). Similar to spring-sown crops, re-crop winter wheat failed in the 2001 crop year. Winter wheat, grown after 4 years of continuous spring cropping where annual grass weeds were not present, was heavily infested with downy brome. Winter wheat seedlings following back-to-back broadleaf crops survived the winter under 100+ days of snow cover only to die from Rhizoctonia root rot during the 2-3 leaf stage of growth in early spring. Rhizoctonia occurred in large patches. There are reports in the literature that *Brassica spp.* such as mustard and other deep-rooted broadleaf crops reduce disease pressure and enhance grain yield of the subsequent wheat crop. We have not found this to be true in this study. Considering that broadleaf crops provide no apparent benefit for Rhizoctonia root disease control and leave less soil water available for the ensuing one or two cereal crops, growers in low-precipitation areas on the inland PNW are probably better off to plant continuous cereals.

Objectives

The objective of the study is to determine the long-term feasibility of diverse, cereal-based, direct-seed cropping systems for low-rainfall dryland areas of the inland Pacific Northwest. Specific objectives are to evaluate and compare several long-term direct-seed annual cropping systems on: *i)* root disease, soil moisture dynamics, and grain yield of wheat, *ii)* weed species shifts and weed ecology, *iii)* physical and biological properties of the surface soil, and *iv)* the agronomic and economic of potential as a replacement for the traditional winter wheat-summer fallow system.

Methods and Materials

This study was initiated in 1997 at two locations. The Adams County site is on the Ron Jirava Farm near Ritzville. Precipitation at the Jirava site averages 11.5 inches, elevation is 1850 ft asl, and the soil is a deep Ritzville silt loam. The experimental design is a randomized complete block with four replications. During the first four years (1997-2000) the three spring cropping systems were: *i)* a 4-year safflower – yellow mustard – wheat – wheat rotation; *ii)* a 2-year wheat – barley rotation and; *iii)* continuous wheat. All phases of all rotations were sown each year for a total of 28 plots, each plot 60 ft X 500 ft. All crops are sown with an 8-foot-wide Cross-slot drill which delivers seed and all fertilizer in one pass. Fertilizer rate (nitrogen, phosphorus, and sulfur) is held constant in all plots and is based on nutrient and soil moisture availability.

The first four years of cropping systems research were completed in 2000 (i.e., one cycle of the 4-year rotation). A committee of growers and scientists extended and expanded the project for years 2001-2004. Beginning with the 2001 crop year, the experiment includes two 4-year rotations, two 2-year rotations using soft white and hard white spring wheat and spring barley, and continuous soft white and hard white spring wheat (Table 1). Both 4-year rotations contain winter wheat. Expansion of the project in phase II was possible because the original plots were wide. Starting in year 5 (2001), we split each plot to create 30 ft x 500 ft strips (total = 56 plots). We were able to create the additional treatments and still have four replicates; thus, the statistical precision of the experiment was maintained.

Table 1. Previous (1997-2000) and current (2001-2004) crop rotations in the long-term cropping systems study at the Ron Jirava farm in Adams County, Washington. All phases of each rotation are planted every year in 500-ft-long plots, each replicated four times.

Years 1997 through 2000	Years 2001 through 2004
Four-Year Rotations	
1. Safflower-YM-SWSW-SWSW	1. SWWW-SWWW-SWSW-SWSW
	2. SWWW-SB-YM-SWSW
Two-Year Rotations	
2. SWSW-SB	3. SWSW-SB
	4. HWSW-SB
Continuous Spring Wheat	
3. Continuous SWSW	5. Continuous SWSW
	6. Continuous HWSW

Abbreviations: HWSW, hard white spring wheat; SB, spring barley; SWSW, soft white spring wheat; SWWW, soft white winter wheat; YM, yellow mustard.

Results

Crop Yields. Grain yields for all years at the Adams county site are shown in Table 2. In 2001, grain yield for all crops was very low due to drought conditions. Total crop-year precipitation (1 Sept. 2000 to 31 Aug. 2001) was only 8.0 inches. There was an average of only 2.25 inches of available soil water in the six-foot soil profile in mid March 2001 and only 2.44 inches of rainfall occurred between mid March and August. Green patches of healthy spring wheat and barley were surrounded by vast areas of drought stressed wheat. These "leopard spots" occurred widely throughout the inland PNW wheat region in 2001 and are certainly associated with drought, but their exact cause remains a mystery. Numerous lifelong growers reported that they had never previously seen such leopard spots in their fields.

Re-crop winter wheat grain yields were 7 bu/a or less in 2001 (Table 2). Many winter wheat seedlings survived the winter months only to be killed by Rhizoctonia root rot in early spring. There was heavy downy brome infestation in winter wheat grown after four years of continuous spring wheat during which time downy brome was completely absent. Downy brome infestation was not as bad in winter wheat grown after yellow mustard compared to after continuous spring wheat, but Rhizoctonia root rot was more severe (see Rhizoctonia section of this report). The best cereal yields (14 bu/a) were achieved in the continuous soft white spring wheat plots (Table 2).

Table 2. Crop yields at the Ron Jirava farm in Adams County, Washington, since beginning the cropping systems study in 1997. The 2001 crop year was a transition period where two new four-year rotations were introduced.

Rotation	Units	1997	1998	1999	2000	2001	5-yr Avg.
1. Four-year							
Safflower	lb/a	1420	720	1040	600		
Y. mustard	lb/a	1430	340	110	490	350	540
1st yr wheat	bu/a	---	41	27	40	8	
2nd yr wheat	bu/a	---	---	25	38	6	
2. Two-year							
Wheat	bu/a	---	40	28	44	12	
Barley	ton/a	2.30	1.13	0.76	1.30	0.35	1.17
3. Cont. wheat	bu/a	64	41	27	43	14	38

Also in 2001: Winter wheat after 4 years of continuous spring wheat = 7 bu/a.
Winter wheat after back-to-back broadleafs (i.e., safflower and YM) = 5 bu/a.
Hard white spring wheat after barley = 10 bu/a.
Hard white spring wheat after back-to-back broadleafs = 6 bu/a.

Impacts of Rhizoctonia Root Rot. Percent land area infected by Rhizoctonia root rot at the Adams County site has been presented in previous WSU Field Day reports. It is highly unlikely that the severe patches caused by Rhizoctonia solani AG8 in the first wheat crop following two consecutive broadleaf crops were due to survival of the pathogen in old wheat residue over the two years since wheat was last grown in these plots. Even a short period of fallow can greatly reduce the severity of this disease. It seems more likely that, since all crops in these systems are hosts and since the period of time from planting (mid March to early April) to harvesting (August for mustard, barley, and wheat and September for safflower) was approximately the same, the amount of primary inoculum for production of Rhizoctonia root rot in the next crop was also then approximately the same.

The wide host range of *R. solani* AG8 has been well documented. Nevertheless, different kinds of crops have diverse effects on the soil environment, they have tap versus fibrous root systems, and they produce various amounts of crop residue or the residue decomposes at different rates when left on the soil surface in direct-seed systems. Depending on the extent of these differences, the amount of disease in this low-precipitation area could also differ, at least between systems as dissimilar as our original (1997-2000) 4-year rotation and the continuous wheat system. The original 4-year rotation was designed to augment any benefit of broadleaf crops for control of root disease by including two broadleaf crops back-to-back before returning to wheat. Previous studies on rotational effects of broadleaf crops have been limited to a single broadleaf crop as a break crop before wheat.

In spite of the differences in crops and rotations, the incidence and severity of both Rhizoctonia root rot were similar if not the same on wheat whether the cropping system was continuous wheat, a 2-year barley – wheat rotation, or a 4-year safflower – mustard – wheat – wheat rotation. In this study, broadleaf crops provided no benefit for Rhizoctonia root disease control and left less soil water available for the ensuing one or two cereal crops, thus growers in low-precipitation areas on the inland PNW are probably better off to plant continuous cereals.

PRECIPITATION AND EVAPORATION IN FIVE DRYLAND CROPPING ZONES IN THE WESTERN UNITED STATES

William Schillinger, Robert Papendick, Stephen Guy, Paul Rasmussen, and Chris van Kessel

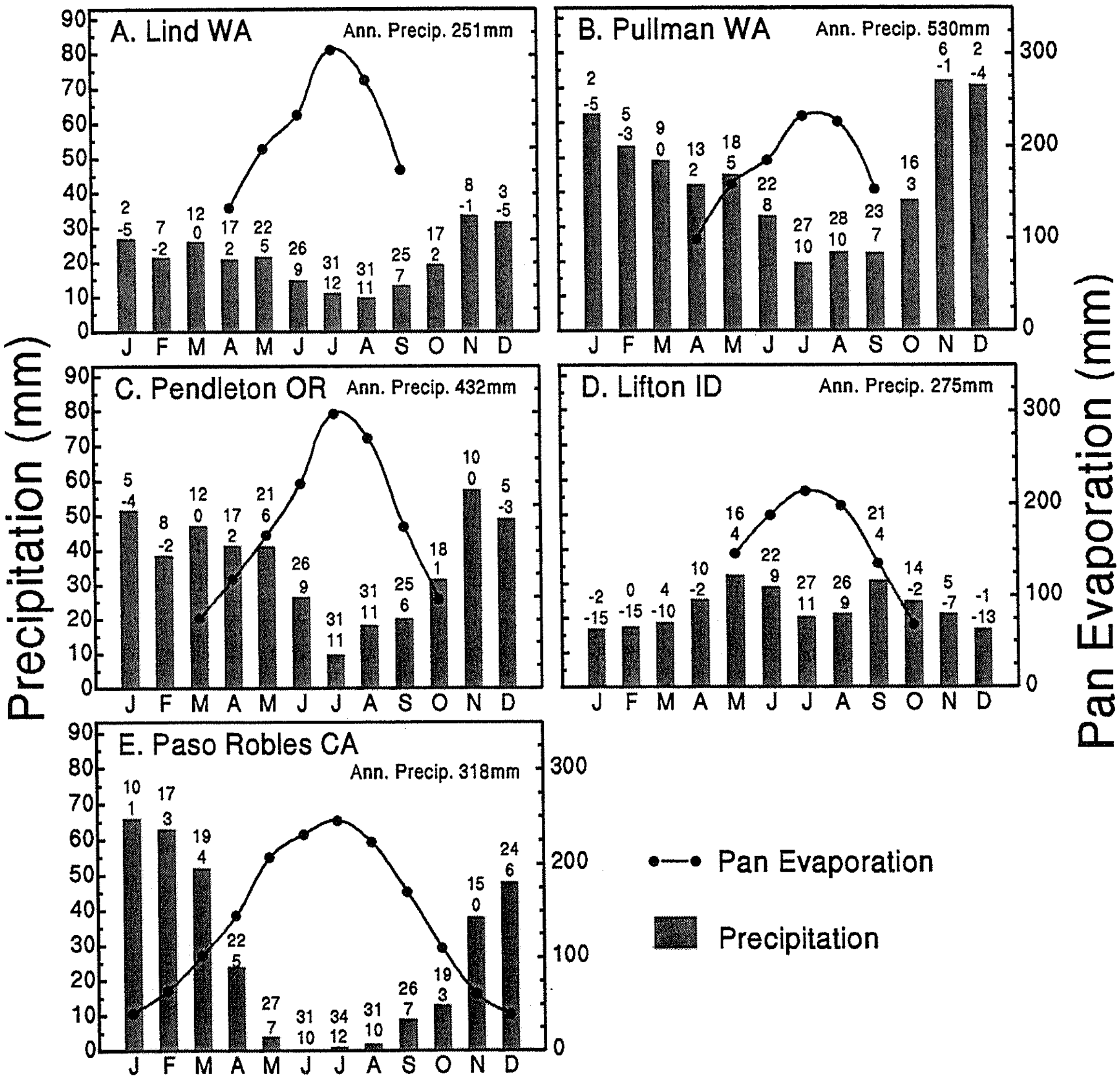


Figure 1. Mean monthly precipitation (30 yr) and pan evaporation (15-yr) from five dryland cropping areas in the Western United States. Numbers above individual bars are mean monthly maximum and minimum air temperature.

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IRRIGATED CROPPING SYSTEMS RESEARCH AT LIND

Researchers: William Schillinger, Harry Schafer, Bruce Sauer, Tim Paulitz, Ann Kennedy, Doug Young, Steve Schofstoll, Don Wysocki, Keith Saxton, Brian Fode, Kurt Schroeder, and Candis Claiborn.

Grower Advisors: Neil Fink, Clark Kagele, Keith Schafer, Jeff Schibel, Gary Schell, John Aeschliman, Perry Dozier.

Summary of Research Findings

An irrigated cropping systems study was initiated in 2000 at the WSU Dryland Research Station at Lind. The crop rotation is 3-year winter wheat – spring barley – winter canola sown *i*) directly into standing stubble, *ii*) after mechanical removal of stubble, or *iii*) after burning the stubble. The traditional practice of continuous annual winter wheat sown after burning and moldboard plowing is also included as a check treatment. First year (2001) grain yields averaged across residue and soil management treatments was 74 bu/a for winter wheat, 2.93 t/a for spring barley, and 2450 lb/a for canola with no significant yield differences within any crop. Winter wheat yields were lower than anticipated due to a late May frost. Over-winter water storage/retention was significantly reduced in all in plots where residue was burned in the fall. For winter wheat as well as for spring barley, Rhizoctonia and take-all root disease were low in all residue management treatments.

Objectives

Many deep-well irrigators in east-central Washington practice a continuous winter wheat rotation (i.e., grow winter wheat on the same field every year). Irrigated wheat grain yields range from 90- to 140-bushels per acre with residue production of 10,000 pounds or more per acre. After grain harvest in August, the traditional practice is to burn the stubble and invert the surface soil with moldboard plow tillage in preparation for sowing in September. Generally, growers feel they need to burn their fields because high residue levels hamper sowing. Alternatives to field burning are needed to reduce smoke emissions and maintain air quality.

Another reason why irrigated growers burn and moldboard plow winter wheat stubble is to control downy brome, a winter annual grass weed. Previous research has shown that long-term control of downy brome is very difficult in continuous irrigated winter wheat using direct seeding. Therefore, new crop rotation and stubble management strategies are needed to make direct seeding (without burning) work.

The objective of this long-term (6-year) project is to determine the feasibility of direct seeding into high levels of residue as a substitute for burning in irrigated cropping systems. Specific objectives are to:

1. Test a 3-year crop rotation of winter wheat – spring barley – winter canola. Crops will be sown with a Cross-slot direct-seed drill into *i*) standing stubble, *ii*) after mechanical removal of stubble, and *iii*) after burning the stubble. An additional treatment of annual winter wheat sown after stubble burning + moldboard plowing (sown with a double-disc drill) will be included as a check.

2. Evaluate and develop effective techniques for sowing crops into heavy surface stubble using direct seeding methods.
3. Document cumulative effects of a diverse direct-seed crop rotation under three stubble management practices on soil physical and biological properties, water use efficiency, diseases, weed ecology, and farm economics. Compare these effects to those under the check treatment (i.e., continuous winter wheat after stubble burning + moldboard plowing).

Materials and Methods

This study was initiated on 10 acres of prime cropland at the Washington State University Dryland Research Station at Lind. To obtain baseline residue levels to begin the experiment, the entire 10 acres was planted uniformly to Madsen winter wheat in September 1999. Grain yield (harvest August 2000) was 110 bu/a and straw production exceeded 10,000 lb/a.

Beginning in the 2001 crop year, a 3-year crop rotation of winter wheat – winter canola – spring barley was grown under three stubble management methods. These are sowing crops: *i*) directly into standing stubble, *ii*) after mechanical removal of stubble (i.e., after swathing and bailing), and *iii*) after burning of stubble. A check treatment of continuous annual winter wheat sown after stubble burning + moldboard plowing is also included. The experimental design is a split-split plot with four replications. Each portion of the 3-year direct-seed crop rotation in each stubble management method is sown each year. Thus, there are 40 plots (3 crops x 3 stubble management practices + the check continuous winter wheat x 4 replications).

Results and Discussion

2001 Crop Year. Hand broadcasting winter canola and then applying irrigation water resulted in spotty and inadequate stands. For this reason, spring canola was substituted for winter canola in 2001. We also had difficulty planting winter wheat into fresh winter wheat stubble in excess of 10,000 lb/a (this is not part of the crop rotation, but was necessary in the fall of 2000 to begin the rotation cycle). Planting spring barley into winter wheat stubble was not a problem because over-winter decomposition made the straw fairly friable. The Cross-slot direct-seed drill did not do well in the traditional check plots that had been burned and moldboard plowed. Grain yields for the 2001 crop year are shown in Table 1. Winter wheat suffered from frost damage during flowering. There was variability in grain yield among replications, resulting in no significant differences within residue management treatments. Spring barley was a pleasant surprise because it was easy to establish, there were no weeds, and grain yields were excellent. A total of 15 inches of irrigation water (6" fall, 9" spring) plus 8.3 inches of precipitation was used to produce these crops.

Soil Water Content. Soil water content in all 40 plots is measured to a depth of six feet by neutron attenuation in August (just after harvest) and again in April before irrigation water is applied. In April 2001, the stubble burn residue management treatment had an average of 2.1 inches less soil water compared to the standing stubble treatment (Table 2). These data well illustrate the accelerated soil water evaporative loss that occurs over winter from a bare soil surface compared to a soil surface covered with residue.

Table 1. Grain yields of winter wheat, spring barley, and spring canola in 2001 as affected by various stubble and soil management practices.

	Winter Wheat (bu/a)	Spring Barley (ton/a)	Spring Canola (lb/a)
Stubble burned	85	2.88	2574
Stubble mechanically removed	67	3.03	2486
Standing stubble	69	2.88	2282
Continuous burn & plow	75		
LSD (0.05)	NS	NS	NS

Table 2. Soil water content in the 6-foot profile in April 2001 (before spring irrigation) and in August after grain harvest with three crops and various stubble and soil management practices. The stubble was 10,000 lb/a from winter wheat in the 2000 crop year.[x]

	Winter Wheat		Spring Barley		Spring Canola	
	inches[y]					
	Apr	Aug	Apr	Aug	Apr	Aug
Stubble burned	8.58 c	5.21 b	10.72 b	5.84 a	9.68 b	3.96 b
Stubble mechanically removed	10.45 ab	5.39 b	12.70 a	6.58 a	11.33 a	4.81 ab
Standing stubble	11.62 a	6.45 a	13.00 a	6.04 a	11.84 a	5.35 a
Cont. burn & plow	10.01 b	6.63 a				

[x] Within-column averages followed by a different letter are significant at the 5% level.
[y] All plots received six inches of irrigation water in September 2000.

Weeds. Weeds within a 3 sq. yard area were identified by species, counted, and collected just before grain harvest in all plots. Samples were allowed to dry in a low-humidity greenhouse for several weeks before recording their dry weight. Weeds per unit area were lowest in the burn direct seed and burn + moldboard plow winter wheat treatments but there were no differences in spring barley or spring canola (Table 3). We achieved excellent stands of spring barley and there were no weeds in any of the residue management treatments for barley (Table 3).

Table 3. Weeds per unit area in winter wheat, spring barley, and spring canola measured just before grain harvest in 2001 as affected by various stubble and soil management practices.[x y]

	Winter Wheat	Spring Barley	Spring Canola
	Number per 3 sq. yards		
Stubble burned	1.3 a	0.0 a	4.7 a
Stubble mechanically removed	15.0 b	0.0 a	7.2 a
Standing stubble	14.0 b	0.0 a	11.0 a
Continuous burn & plow	2.7 a		

[x] Within-column averages followed by a different letter are significantly different at the 5% probability level.

[y] Percentage composition of weed species in the total population averaged across treatments was: downy brome, 42.7% (but found only winter wheat); Russian thistle, 13.6%; prickly lettuce, 10.4%; mares tail, 9.5%; other weeds, 23.8%. Other weeds were tumble mustard, tansy mustard, wild oat, field pennycrest, western salsify, and sowthistle.

Diseases. For winter wheat, the least take-all was measured in the standing stubble, whereas the least Rhizoctonia was in the stubble burned treatment (data not shown). The total root length and surface area were less in the burn + moldboard plow treatment compared to the standing stubble and mechanical stubble removal treatments (data not shown). These data paralleled the data for number of tillers (i.e., the standing stubble and mechanical removal had a greater number of tillers). These differences are probably a reflection of plant stand (data not shown) which was greatest in the burn direct seed and burn + moldboard plow treatments.

For spring barley, the levels of take-all were extremely low compared to winter wheat. Rhizoctonia levels were higher on barley compared to winter wheat, but there were no differences among residue management treatments in spring barley in terms of root infection, number of crown roots, or number of tillers. The same lack of difference was seen in root length measurements (data not shown) where overall levels of Rhizoctonia and take-all were low in all residue management treatments. The only disease data available with canola is for Rhizoctonia. More Rhizoctonia was isolated from the standing stubble than from the other residue management treatments (data not shown).

2002 Crop Year. Due to the failure to achieve adequate stands of winter canola following winter wheat in 2000, project researchers and growers decided to modify the crop rotation. Instead of winter wheat – winter canola – spring barley, the new rotation (which began in August 2001) is winter wheat – spring barley – winter canola. We had very good success sowing winter canola into barley stubble just after harvest and then applying six inches of irrigation water. The flush of volunteer barley that occurred after irrigating was controlled with Assure II grass herbicide. Winter canola stand establishment in 2001 in all residue management treatments was adequate (data not shown). We had no difficulty sowing spring barley into winter wheat stubble (after it had a winter season to partially decompose) during the first year of the study; thus, we have confidence in this method. Similarly, sowing winter wheat into canola stubble presents no problem.

CROPPING SYSTEMS RESEARCH IN THE DRIEST WHEAT REGION OF THE WORLD

Bill Schillinger, Doug Rowell, Harry Schafer, Doug Young, Steve Albrecht, and Steve Schofstoll

Summary of Research Findings: For the third year in a row, less than five inches of precipitation occurred during the crop year (1 Aug. 2000 to 31 July 2001) at the Doug Rowell cropping systems site in the Horse Heaven Hills, Washington. Grain yields in 2001 were: continuous annual dark northern spring wheat (DNS), 0.6 bu/acre; recrop soft white winter wheat (SWWW) after spring wheat, 0.5 bu/acre and; SWWW after summer fallow, 2.4 bu/acre. An economic analysis of this experiment by Doug Young et al. in 2001 showed that, between 1997-2000, continuous DNS lagged behind SWWW – summer fallow in profitability by about $40 per acre. Recrop SWWW was more competitive against Russian thistle than continuous DNS, but the severe ongoing drought caused crop failure in all treatments in 2001. This 6-year study will be completed after the 2002 crop year. Growers in the Horse Heaven Hills have advised that, even if annual direct-seeded wheat should become more competitive after many years of direct seeding, they cannot afford the go through the transition period.

Objective: The objective of this long-term experiment is to compare the traditional SWWW – summer fallow rotations with: i) continuous annual direct seeded DNS and; ii) a continuous annual direct seeded SWWW – DNS rotation for wheat grain yield, water use efficiency, control of Russian thistle, and farm economics. The Horse Heaven Hills encompasses approximately 300,000 cultivated dryland acres. This region receives less precipitation than any other non-irrigated cereal production region of the United States, and most likely the world. The long-term average precipitation at the research site on the Doug Rowell farm is only 6.5 inches per year. Low production of crop residue and repeated drought cycles, combined with a tillage during the fallow period, often leaves the soils vulnerable to wind erosion due to lack of residue cover, clods, and roughness.

Materials and Methods: In collaboration with Doug Rowell and the Benton County Wheat Growers Association, a 6-year experiment was initiated in February 1997. The experiment compares the traditional winter wheat – summer fallow rotation to continuous direct-seeded dark northern spring wheat. Beginning in 2000, a continuous direct seed winter wheat-dark northern spring wheat rotation was added. Both the crop and fallow phases of the wheat – fallow rotation are present each year. The experimental design is a randomized complete block with six replications (total of 28 plots). The study covers 8 acres with each plot 300 feet long. Historic winter wheat yields at the site had ranged from 3 to 30 bushels per acre. The Warden silt loam soil (coarse-silty, mixed, mesic Xerollic Camborthids) is more than six feet deep with a slope of less than two percent.

Equipment and field management for the wheat – fallow system are provided by Rowell. Tillage operations entail primary spring tillage in March with a V-shaped sweep implement or tandem disk, followed by 2 or 3 rodweedings as needed during the late spring and summer to control Russian thistle. Fertilizer is not used during dry years. Winter wheat is sown with a deep furrow drill in August if adequate seed-zone moisture is available, or with 10-inch hoe drills after the onset of rains in October or November. In-crop broadleaf weeds are controlled with 2-4,D herbicide.

In the direct-seed treatments, DNS is sown in February or early March with a low-disturbance Cross-slot drill. The Cross-slot is equipped with notched coulters on 8-inch row spacing that deliver seed and liquid fertilizer in one pass. Soil tests for soil moisture and nutrient availability are taken just prior to sowing each year to determine an optimum fertilizer rate based on 3.5 lbs of nitrogen for each expected bushel of wheat production for 14% grain protein. Two or three herbicide applications are required each year for the direct-seed continuous spring wheat system: a pre-plant glyphosate application if downy brome is present, an in-crop broadleaf herbicide, and a post-harvest burn-down herbicide for Russian thistle control. Winter wheat in the SWWW – DNS direct-seed treatment is sown in late October after the onset of fall rains.

Results and Discussion: Only 4.36 inches of 2001 crop-year precipitation occurred and wheat failed in all treatments (Table 1). Only one inch of available water was stored in the soil over the winter. The 5-year average grain yields for winter wheat after fallow is 19.7 bu./acre compared to 8.4 bu./acre for continuous DNS wheat. Recrop winter wheat and spring wheat had essentially died from drought stress before entering the grain fill stage of development.

Ponded water infiltrometer measurements in the early spring of 2001 and 2002 showed no differences in water infiltration rate into the soil between winter wheat stubble (in SWWW – fallow rotation) and continuous direct-seeded DNS wheat stubble. Soil penetrometer resistance was significantly greater in the surface nine inches in plots that had been direct-seeded for the past five years compared to the winter wheat – fallow treatment (data not shown).

An economic analysis by Doug Young et al. (2001) for the Rowell experiment showed that profitability of the continuous DNS wheat system lagged behind the traditional winter wheat fallow rotation by $40/acre per year. Detailed data on soil water dynamics, Russian thistle growth and ecology, and grain yield components (data not shown) have been collected every year from this experiment. Popular and refereed journal articles from this 6-year study will be written following completion of experiment in July 2002.

Table 1. Precipitation, wheat grain yields, and DNS wheat grain protein in the Horse Heaven Hills cropping systems study, 1997-2001.[x]

Year	Aug.–July Precip. (in.)	Wheat Yield (bushels/acre) SWWW after fallow	Cont. SWWW–DNS	Cont. DNS	DNS Protein (%)
1997	9.44	26.5		13.7	10.5
1998	7.87	41.2		18.0	12.4
1999	4.24	8.5		3.8	14.6
2000	4.76	19.8		5.9	14.1
2001	4.36	2.4	0.5	0.6	14.8
5-yr avg.	6.13	19.7		8.4	12.9

[x] Abbreviations: SWWW, soft white winter wheat; DNS, dark northern spring wheat.

THE UTILIZATION OF SEED PLACED LIME TO REDUCE THE ACIDIFYING AFFECT OF NITROGEN FERTILIZERS IN DIRECT SEEDING SYSTEMS

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Introduction: In eastern Washington State, direct seeding can decrease soil erosion, increase plant available soil moisture, improve soil quality, and increase the sustainability of agriculture. With the implementation of direct seeding practices and the continuous use of ammoniacal fertilizers, acidic soil conditions may become a limiting factor in crop production. The conversion of ammonium, found in nitrogen-based fertilizers, to nitrate by microorganisms produces H^+ ions and increases soil acidity. Reduced soil pH can decrease soil nutrient availability, increase risks of mineral toxicity problems (such as Al^{3+} and Mn^{2+}), and decrease crop yields. Therefore, the utilization of liming products to ameliorate the buildup of acidic soil conditions was assessed. Broadcast application of lime to the surface of the soil is impractical in direct seeding; thus, the use of pelletized lime in the seed row and the effect of this application of lime to reduce the acidifying affects of nitrogen fertilizers was evaluated.

Objectives: The major objective of this research was to determine the effect of seed placed lime and ammonium phosphate-sulfate starter fertilizer on soil pH, extractable aluminum, and ammonium and nitrate content of two soils in the Palouse region of eastern Washington State. Grain yield and grain protein content for wheat (*Triticum aestivum* L.) was also investigated to ascertain if either of these two parameters would be influenced by the application of lime or starter fertilizer in the seed row.

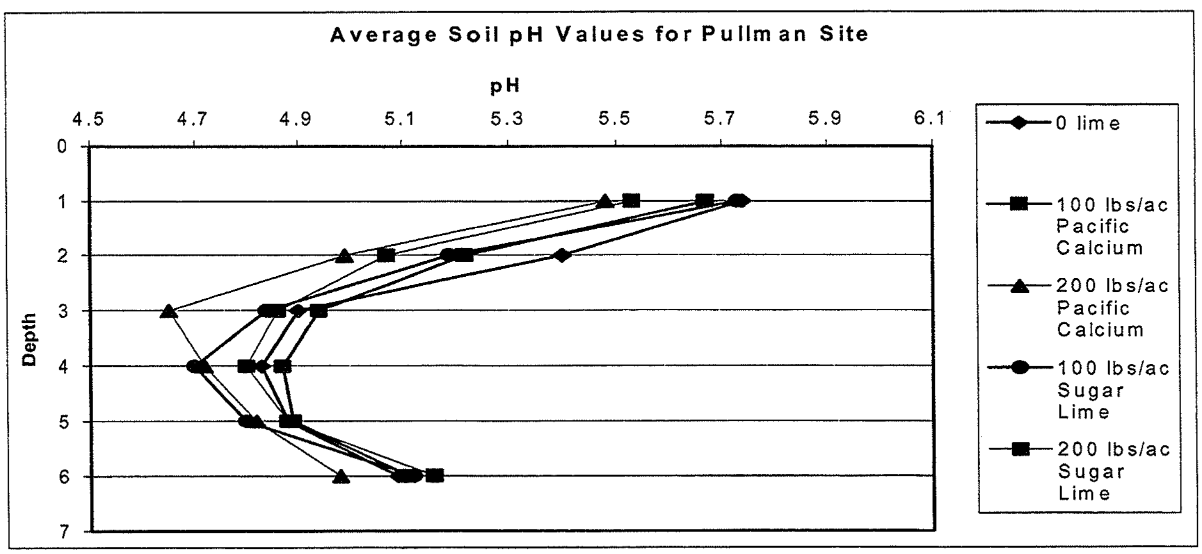
Materials and Methods: Sites were established on two farms in eastern Washington State in the fall of 2000, Palouse and Pullman, and initial pH values were determined for the sites with averages of 5.62, 5.11 and 5.32 at Palouse site and 5.34, 4.94, and 5.48 at Pullman site at depths of 0-2 inches, 2-4 inches, and 4-10 inches respectively. Research plots contained 60 treatments within a 150 by 150-foot block at each site. Treatments consisted of applications of lime at rates of 0, 100, or 200 lbs/ac., with or without ammonium phosphate-sulfate starter fertilizer (16-20-0). Two sources of pelletized lime, Pacific Calcium and sugar beet lime, were utilized in this study. The remaining nitrogen was applied as urea at 100 lbs N/ac 3 to 5 inches below the seed. The wheat varieties planted, Madsen, Soft White Winter Wheat at the Palouse site, and Columbia 1, Hard Red Winter Wheat at the Pullman site, were determined by the growers. Soil cores where taken to a depth of 6 inches one month after planting, November 2000, and directly following harvest, August 2001. The cores were then divided into 1-inch increments and air-dried. From these soil cores, soil pH, extractable aluminum, and ammonium and nitrate levels were determined. After harvest, grain yield and grain protein content were determined for each site and wheat variety.

Results: Neither starter fertilizer nor lime application had a statistically significant effect on soil pH for the soil cores taken one month after planting. During the processing of these cores, numerous un-reacted lime pellets where observed indicating that the lime had not dissolved or reacted completely with the soil. Therefore, the lack of significant differences in soil pH one month after planting may be a result of insufficient time for the lime to react with the soil. Figures 1 and 2 illustrate the average soil pH values for the two sites, Pullman and Palouse. Due to the lack of significant difference from the application of starter, pH values were grouped by lime rate to allow for ease of viewing. Although there seems to be a substantial difference for the 100lbs/ac of sugar lime as compared to the other application rates, there was no statistical significance for this treatment. This visible increase in pH may be a result of un-reacted lime pellets being inadvertently included in the pH analysis of these samples.

Neither the application of starter fertilizer nor the application of lime had a statistically significant effect on grain protein content or grain yield, as can be seen in figure 3. Yields and protein content were very similar for all treatments and little variability was found. The difference in grain yield between sites was a product of the different varieties that were planted.

The second set of soil cores did show a statistically significant difference between the applications of starter fertilizer to a depth of 3 inches. Analysis of the data showed that with the application of starter fertilizer there was a decrease in soil pH. This is a result of the acidifying nature of the starter fertilizer that was utilized in this study. Figure 4 illustrates the effect of starter fertilizer and lime application on soil pH at the Palouse site. This figure clearly demonstrates the reduction of soil pH with the application of starter and no lime application.

Continuing Research: Ongoing research includes the determination of extractable aluminum as well as the ammonium and nitrate levels for all soil. Further experiments will also be conducted to determine a buffering curve and the amount of extractable aluminum in soils collected from the Palouse field site. These soils will be acidified to desired levels and stated information will be obtained from them. Additionally, long-term application of variable rates of seed placed lime will be investigated to determine the effect of extended utilization of this amendment.



Figures 1. Average soil pH values for soil cores taken at the Pullman site 1 month after planting. No statistically significant differences were noted for lime application or starter fertilizer use.

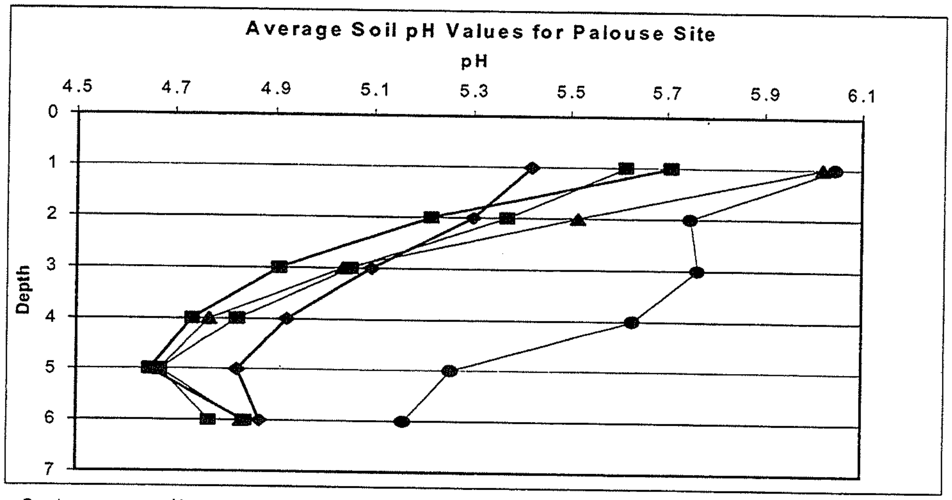


Figure 2. Average soil pH values for soil cores taken at the Palouse site 1 month after planting. No statistically significant differences were noted for lime application or starter fertilizer use.

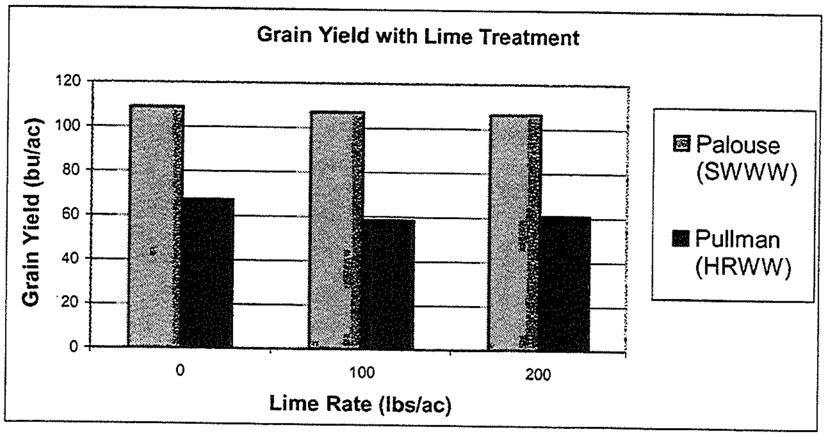


Figure 3. Yield of grain as related to lime application. Neither the application of lime nor starter fertilizer (APS) had a statistically significant influence on yield.

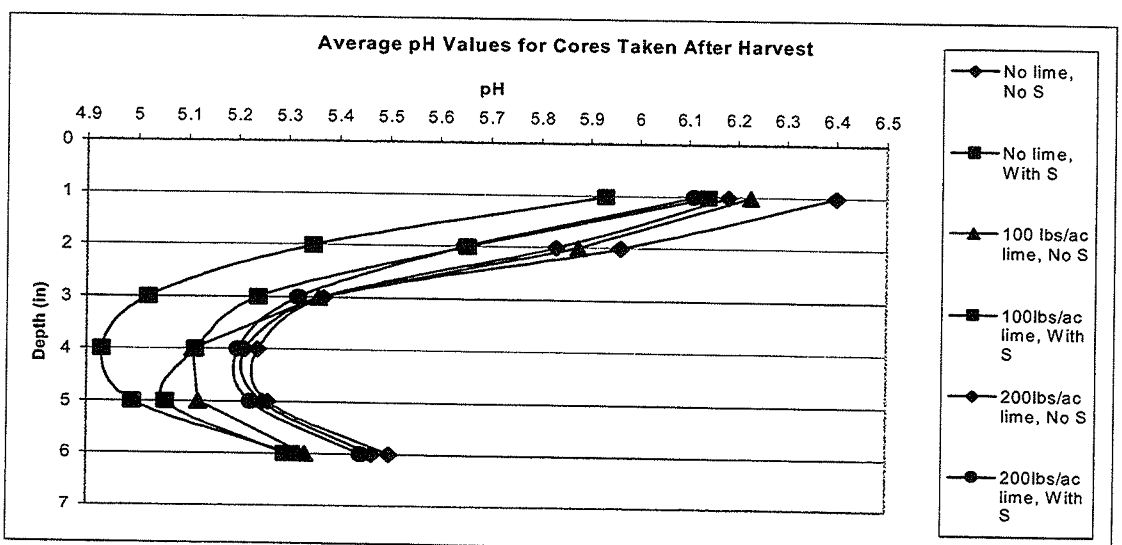


Figure 4. Average pH values for the Palouse site, grouped by source of lime, showing the influence of starter fertilizer (APS) on the soil acidity.

PERFORMANCE OF ADVANCED LINES AND VARIETIES OF SPRING AND WINTER WHEATS SEEDED DIRECTLY INTO CEREAL STUBBLE

R. James Cook, Kim Campbell, Steve Jones, and Kim Kidwell

Efforts have been underway for the past several years to evaluate the performance of a limited number of advanced lines and standard varieties of spring and winter wheat under direct-seed conditions in the field. Current tests are conducted at Bickleton in cooperation with Steve Matsen, Colfax in cooperation with John and Cory Aeschliman, and on the Palouse Conservation Field Station and Cunningham Agronomy Farm, both near Pullman. Each site has been under direct seeding for several years and presumably has undergone the so-called "transition" phase.

All tests have been done without burning the stubble. Furthermore, all fertilizer has been placed within the seed rows and directly below the seed at the time of planting, with N rates based on soil tests. Soil fumigation has been included at some sites to evaluate the level of root disease pressure (see Table 1). Two different drills have been used, depending on the design of the test and the site. One drill is an 8-row cone seeder equipped with either Yetter coulters (for spring seeding; Tables 2 and 3) of shanks for fall seeding (Table 4) to place fertilizer below the seed in front of Acra-Plant openers, all on 12-inch spacing (drill similar to the McGregor one-pass drill). This drill is used to plant plots typically 8 rows wide and 24 feet long. The other drill is an air-seeder equipped with Anderson openers for simultaneous placement of seed above a fertilizer band in paired rows spaced 12 inches apart (Table 5). This drill is used to test varieties in replicated drill strips 8 feet wide and 100 feet long, or longer. As the WSU Extension variety test program shifts more into direct seeding, these tests under direct seeding are shifting towards more use of drill strips planted with the air seeder and are limited to a more select group of varieties and advanced lines of the three wheat breeding programs.

In general, the yields of both the spring and winter wheat varieties have been similar to yields with conventional tillage and planting (Tables 2, 3, 4 and 5). Furthermore, the highest-yielding varieties under direct seeding tend also to be the highest-yielding varieties under conventional seeding.

Spring wheat yields at the Colfax site were exceptional in 2000 (Table 4), especially considering that the plot site was in a field managed as continuous direct-seeded cereals for the past 9 years (no fallow and no broadleaf break crops: John and Cory Aeschliman farm). The yields on the Pullman site (Palouse Conservation Field Station) for winter wheat in 1998 and 2001 and spring wheat in 1999 and 2000 represent the 17th, 18th, 19th [a] and 20th consecutive years of continuous no-till at this site and the 14th, 15th , 16th and 17th wheat crops, respectively, in these 20 years. The winter wheat planted in this site in the fall of 1999 was sprayed out in February 2000 because of excessive volunteer spring wheat and then planted to spring wheat (yields shown in Table 3). The low yields of winter wheat at the Colfax site in 1999 (Table 4) were due primarily to poor stands because of an inability of our small cone seeder to plant through the heavy residue. This has not been a problem for most commercial no-till drills. The low yields at the Bickleton site for both spring and winter wheat in 2001 (Table 5) were due to the drought at this location;

total precipitation from September 2001 through May 2002 was only about 5 inches. Keep in mind that all of these sites are recropped with no fallow break.

Root diseases, including Rhizoctonia root rot, Pythium root rot, take-all, and Fusarium root and crown rot are among the major constraints to yields of both winter and spring wheats planted directly into cereal stubble without benefit of fallow or a broadleaf crop in the rotation. With seed treatments such as Dividend + Apron (or Dividend XL) and Raxil XT, the yields of both spring and winter wheat have been about 75-80% of the potential as revealed in experimental plots with fumigated soil (Table 1).

Table 1. Yield changes (+/-) from a nontreated check in response to soil fumigation and seed treatments for spring and winter wheats at five locations (Bickleton, Dusty, Colfax, Pullman, and Troy) over the years 1993-1996.

	Spring wheat				Winter wheat			
Treatment	%[a]	(no.)[b]	bu/acre[c]	*P*value[d]	%[a]	(no.)[b]	bu/acre[c]	*P*value[d]
Fumigation	32	35	15.6	<0.01	24	39	13.5	<0.01
Dividend + Apron	8.1	20	3.9	0.03	3.1	32	2.8	0.10
Raxil XT	5.7	16	2.5	0.32	9.5	33	3.3	0.13

[a] Percentage change in grain yield from nontreated check.
[b] Number of paired comparisons.
[c] Actual change in grain yield compared to nontreated check.
[d] P value based on a t-test that compared the treated with its corresponding untreated check for each year, location, and replicate.

Table 2. Average yields of spring wheat lines and varieties seeded directly (no-till) into standing stubble of winter or spring wheat as small (8' x 24') replicated plots.

	Palouse Conservation Field Station[a>]		Spillman	----------Bickleton----------			------Colfax------	
	1999	2000	1999	1998	1999	2000[b>]	1998	1999
Variety				(bu/A)				
Penawawa		50.6		18.3			45.8	
Edwall				20.7			46.3	
Pomerelle				14.8			37.4	
Centennial							48.1	
Vanna				18.4			37.9	
Alpowa	63.9	44.8	71.5	20.7	43.2	26.7	47.2	59.9
Wawawai		38.9	72.7	32.1		25.9	46.9	
Whitebird				15.5			47.1	
ID3775				16.9			50.1	
WPB926	67.5		50.4	29.4	35.3		55.4	47.4
Express				18.7			47.2	
Zak	67.2		72.4	32.9		29.7	52.4	58.0
Westbred 936				17.0			46.1	
Butte 86				21.6			45.9	
WA7802				20.8			52.2	
WA7824	66.7	46.9	66.6	29.8	39.2		55.4	56.0
WA7839						24.1		
WA 007873	60.8		61.6		34.5			45.9
WA 007874	50.9		57.1		40.1			43.9
WA 007875	59.2		64.2		33.8			51.3
WA 007876	51.4		50.7		32.2			42.3
WA 007878	69.9		64.5		40.4			49.5
WA 007879	61.4		78.5		34.4			61.7
WA 007880	67.6		74.0		34.6			53.3
WA 007881			69.1		38.6			56.7
WA 007882			66.6		37.3			50.9
WA 007864	69.4		72.4		35.9			55.1
PI 601814	64.1		60.9		33.4			49.6
WA 007841	52.6		55.1		30.9			46.3
Average	62.3	45.3	65.2	21.8	36.2	26.6	46.7	51.7

[a>] The years 1999 and 2000 at this site represent the 18th and 19th consecutive years of no-till and the 14th and 15th wheat crops in the past 19 years.

[b>] Seeded as 100-foot-long drill strips, 8 feet wide, replicated four times. All other tests were seeded with small plot drill 8 rows wide and 24 feet long, replicated six times.

Table 3. Yields and grain protein of select varieties and advanced lines of spring wheat seeded directly into standing wheat stubble as small (8' x 24') replicated plots.

		Palouse Conservation Field Station		Colfax			
		-----------2000---------		------------2000----------		------------2001-----------	
Variety/ Advanced Line	Class	Yield (bu/A)	Protein %	Yield (bu/A)	Protein %	Yield (bu/A)	Protein %
Alpowa	SWS	44.8	11.2			65.1	
Matt	Durum	42.8	13.7	69.7	12.5	54.9	13.1
Penawawa	SWS	50.6	11.1				
Wawawai	SWS	38.9	11.5				
Winsome	HWS	53.4	12.7	90.8	10.8	64.7	11.9
Tara	HRS	46.9	13.7	82.7	12.5	64.5	
Zak	SWS	47.1	11.8	84.7	11.0	60.5	
7839	HRS	59.1	13.4	87.0	13.0		
7859	HRS	39.7	14.0	72.9	13.0	56.1	15.0
7860	HRS	48.9	13.7	75.5	12.8		
7864	SWS	46.9	11.9	88.2	11.1		
7867	SWS	49.7	11.1	87.5	10.6		
7872	HRS	49.9	13.7	80.8	13.3	58.2	13.6
7874	HRS	56.3	13.3	81.8	13.0	61.3	13.5
7875	HRS	48.1	14.2	79.9	13.0	59.2	13.2
7877	SWS	47.5	12.2	89.3	11.2	63.3	
7879	SWS	44.0	11.1	86.7	10.5		
7883	SWS	48.5	11.3	86.6	10.7	65.1	
7884	SWS	51.7	11.3	90.4	10.5	66.0	
7885	SWS	50.5	11.5	88.9	10.9		
7886	SWS	51.3	11.1	84.5	11.0	60.2	
7887	SWS	45.4	11.2	84.5	10.8	64.2	
7888	SWS	48.7	11.1	88.5	10.6		
7889	SWS	53.4	11.2	88.3	10.8		
7890	SWS	54.2	11.2	88.8	10.5	65.8	
7891	HRS	47.7	13.4	87.6	12.0	60.7	14.4
7892	HRS	51.9	13.8	78.4	12.4	58.5	12.8
7893	HRS	49.8	13.4	78.3	12.5	61.6	13.8
7894	HRS	51.6	13.4	76.2	12.5	61.1	13.8
7895	HRS	49.8	14.3	79.9	13.1	58.4	13.2
7896	HRS	48.6	13.3	89.5	12.2	67.6	13.4
7897	HRS	63.0	13.4	80.6	13.4	58.7	13.4
7898	HRS	55.0	14.2	85.1	13.0	64.4	13.8

Each value is an average based on six replicates (Colfax) or four replicates (PCFS).

Table 4. Average yields of winter wheat lines and varieties seeded directly into standing stubble of spring wheat in small (8' x 24') replicated plots.

	------------ Colfax	-----------		--------- Bickleton	---------		Pullman
	1997	1998	1999	1998	1999	2000[a]	1998
Variety				(bu/A)			
Madsen	72.5	78.6	50.0	38.3	42.5	34.0	82.2
Stephens		77.4	45.0	38.2	48.0		85.7
Estica						41.1	
Eltan	92.7	71.4	60.3	39.2	47.1	41.3	67.0
Moro				31.6			
Hiller	85.3		43.4	38.6	42.8	41.8	75.7
Coda			52.6		47.9	39.0	
Finley						40.2	
Buchanan			51.8		32.4		
WA7835	86.3	78.1		41.2			86.2
Bruehl	80.3	77.9	52.0	40.1	40.3	44.1	76.8
Rely		71.9	43.0	38.0	42.0	38.2	70.2
Rod		75.4	49.9	38.3	43.3	40.7	76.7
WA7834	73.6	59.0		33.1			62.7
WA7752		76.5		41.0			76.3
WA7871						38.0	
WA7786			45.7				
AWO95352						44.1	
Rohde		74.3		37.2			69.5
OR92054		73.6		37.7			76.6
Lewjain			52.6	36.0	43.5		66.1
Symphony						42.5	
VO95433						36.7	
VO95470						36.2	
Average	81.7	74.0	49.7	37.8	43.0	39.9	74.8

Each value is an average of six replicates of 8-row plots 24-feet long.

Table 5. Average yields wheat varieties seeded as replicated drill strips (8' x 100') using an airseeder with Anderson openers directly into standing cereal stubble (no fallow; continuous no-till cereals).

Variety	----Bickleton---- 2000	2001	------Pullman 2001------ PCFS	Cunningham
	(bu/A)			
Winter wheat				
Boundry	30.9			
Bruehl	34.3	11.7	78.7	73.3
Chuckar		10.6		
Coda		9.4		78.0
Eltan	32.1	14.6	80.1	86.7
Finch		12.7		
Finley		12.7		
Madsen	30.8	13.2	83.5	76.0
Rod		12.7	84.0	
Stephens				80.1
Spring wheat				
Alpowa	26.6	7.7		63.9
Hank		7.0		67.5
Jefferson		8.0		
Scarlet	24.3	9.6		
Tara	24.1	6.7		63.8
Wawawai	25.9	6.1		70.5
WPB926				62.5
Zak	29.7	6.2		68.4

YIELD TRENDS IN A LONG-TERM CONTINUOUS DIRECT-SEED WINTER WHEAT/SPRING CEREAL CROPPING SYSTEM

R. James Cook, Ron Sloot, and Ryan Davis

A study was undertaken the fall of 1987 on the Palouse Conservation Field Station near Pullman to evaluate yield trends and root diseases with continuous direct-seeded cereals. The site had already been direct-seeded to winter wheat for five consecutive years (1981-1986) and was then chemical fallowed in 1986-87 prior to launching this study. The current (2002) planting of spring wheat represents the 21st consecutive year where the only tillage performed on this site has been with the drill equipped to plant and fertilize as one-pass. The 2002 spring wheat represents the 19th cereal crop and the 18th wheat crop during the past 21 years. In addition to chem fallow in 1987, the plot was planted to spring barley in 1993, and spring peas in 1994.

Rotations to spring crops have been essential to manage cheat grass and jointed goat grass. For this reason, spring wheat has been planted at least every other year and occasionally as two consecutive crops before returning to winter wheat. Fumigation plots were included as checks during 1987-92, but were then discontinued. Many replicated seed-treatment, variety, row-spacing, and fertilizer-placement studies have been conducted at the site in years past. The site is now used to compare the yields of different varieties under no-till conditions where the soil has long since passed the so-called "transition" phase and associated changes in soil structure and biology with long-term no-till. The study site has never been burned, but has been planted each year across the direction of the rows of the previous year so as to place the maximum amount of seed between rather than within the old stubble rows.

The data in Table 1 are the yields in the untreated (natural soil) and fumigated checks together with six years for data on performance of seed treatments for management of Pythium and Rhizoctonia roots rots, respectively. For each of these yields, rows have been spaced 12 inches apart and fertilizer has been applied directly beneath the seed as a combination of N (solution 32), P, and S based on a soil test and yield goal.

The highest yield of winter wheat (Daws, at 128 bu/A in 1988) and spring wheat (Penawawa, at 99 bu/A in 1995) were following the years of chemical fallow and peas, respectively. This confirms the value in the higher-precipitation region of the Palouse of a break to either fallow or a broadleaf crop before planting wheat, whether winter wheat or spring wheat. There was no response of the Daws to soil fumigation after the 1-year break to chemical fallow nor of the Penawawa to Apron-Terrachlor after the 1-year break to peas, confirming the importance of crop rotation for control of root diseases.

The lowest yields of winter and spring wheat were in the second (Hill-81 at 57 bu/A in 1989) and third (Penawawa at 49 bu/A in 1990) years respectively. In both of these years, there was a large yield response to Apron-Terrachlor, soil fumigation, or both, further confirming the role of root diseases in these yield depressions. The low yield of Penawawa in 1992 was possibly the result of high temperature during grain fill. The first evidence of take-all decline (the spontaneous disappearance of take-all due to microbiological changes in the wheat rhizosphere) appeared in 1996 and was confirmed by Jos Raaijmakers and Dave Weller in 1997 using their lab test.

Table 1. Long-term yield trends in a continuous direct-seed winter wheat-spring cereal cropping system at Pullman, WA (Palouse Conservation Field Station)

	Year	Variety	Check bu/A	w/Apron +Terrachlor or Apron+Dividend bu/A	Fumigated bu/A
1-5	1981-86	Continuous direct-seeded winter wheat; yield data not available			
6	1986-87	Chemical Fallow			
7	1987-88	Daws	128		124
8	1988-89	Hill-81	57	57	72
9	1989-90	Penawawa	49	57	76
10	1990-91	Penawawa	65		86
11	1991-92	Penawawa	55		7
12	1992-93	Steptoe Barley	(~3.0t/a)		
13	1993-94	Peas			
14	1994-95	Penawawa	99	101	Discontinued
15	1995-96	Madsen	87	101	
16	1996-97	Alpowa	69	75	
17	1997-98	Madsen	82	82	
18	1998-99	Alpowa	64	67	
19	2000	Alpowa	52		
20	2001	Madsen	84		

These results suggest that yields of continuous direct seeded wheat can be maintained over the long term, provided that spring cereals are used to manage cheat grass and jointed goat grass. Rotation to broadleaf crops not only breaks up pest cycles, it also disrupts the microbiological process responsible for take-all decline, although the evidence suggests that reestablishment of a take-all suppressive soil is relatively fast during a second and subsequent years of continuous wheat. Growers interested in continuous cereals might consider dedicating and maintaining the same land to a continuous direct-seeded winter wheat/spring cereal cropping system, and maintaining other land, e.g., the most productive land, to a 3- or 4-year direct-seeded, crop rotation.

PERFORMANCE OF ADVANCED LINES AND VARIETIES OF SPRING BARLEY SEEDED DIRECTLY INTO WHEAT OR BARLEY STUBBLE

R. James Cook, Steve Ullrich, and William Schillinger

In addition to erosion control in all agronomic zones, direct-seeding offers the means to increase the diversity and intensity of cropping in areas traditionally dependent on a winter wheat/summer fallow rotation, thereby broadening the economic base of the farm and spreading risks over more crops. Intermediate-precipitation areas that currently use a winter wheat/spring cereal/summer fallow rotation have, with direct seeding, the potential to eliminate summer fallow all together. In the higher precipitation areas, such as the Palouse, where annual cropping is already a common practice, direct seeding offers one of the best means by which to reduce inputs because of fewer passes needed to grow crops.

Spring barley has proven particularly well-suited to direct seeding into cereal stubble. In fact, for those growers that are planning to experiment with direct seeding for the first time, planting spring barley directly into standing stubble of any cereal is probably the best way to start into one of these systems. Rhizoctonia root rot has been the most apparent hazard encountered with direct-seeded barley, but tools such as greenbridge management and fertilizer placement are helping greatly to reduce the risk of this disease. Research and grower experience have shown that virtually any drill equipped to 1) place seed through surface residues into good soil contact, 2) place fertilizer directly below or below and slightly to one side of the seed, 3) loosen soil beneath the seed for seminal root penetration, and 4) clear trash from within the seed row will be acceptable.

Further significant advancements towards achieving the high yields possible with direct-seeded spring barley will come with development of varieties with resistance or tolerance to the hazards encountered with this method of farming. Towards this end, research is underway on two fronts: evaluation of existing varieties to determine their suitability to direct seeding, and identification or development of barley germplasm with resistance or tolerance to Rhizoctonia root rot for use in the breeding program. In addition to greenhouse tests, a field test to screen both spring barley and spring wheat for resistance to Rhizoctonia root rot is under development on Spillman Farm (see article in this Field Day report, "A Development of a Field Screening Method for Resistance or Tolerance to Rhizoctonia Root Rot"). The development of Rhizoctonia-resistant varieties is a long-term effort.

The variety evaluation studies were begun about seven years ago and now include sites near Ritzville and Pullman, representing the low- and high-precipitation areas, respectively. Prior to 2000, we also had test plots at Bickleton and Dusty, but these were discontinued starting in 2001 as the WSU variety testing program has expanded its work into direct-seed systems in these areas. All tests are done with excellent greenbridge management and a one-pass system that seeds and places fertilizer and loosens the soil directly beneath the seed. All tests have been with spring barley seeded directly into cereal stubble. Yields of a select subset of varieties tested to date are presented in Table 1.

In general, the yields have been good to excellent. The low yields at the Ritzville site (Wellsandt Farms) in 2001 were due to a severe water shortage, and the even lower yields at Ritzville following spring wheat (2001b) were probably due to frost damage in addition to drought in this field. The high average yields at Pullman (2001) were produced on the Cummingham Agronomy Farm in a field that has been in continuous cereals for several years and direct-seeded cereals (spring wheat and spring barley) the past 2 years (1999 and 2000). As experienced with conventional seeding, Baronesse has been at or near the highest yielding spring barley in these tests.

Table 1. Yields of spring barley seeded directly into stubble of winter or spring wheat or spring barley.

	Pullman			Ritzville						
Variety	1999 (lbs/A)	2000 (lbs/A)	2001 (lbs/A)	1998 (lbs/A)	1999a (lbs/A)	1999b (lbs/A)	2000a (lbs/A)	2000b (lbs/A)	2001a (lbs/A)	2001b (lbs/A)
Bob (WA8682-96)			5255							
Crest	3500	5800		2644						
Harrington	3640	5060	5581	2549		1960	2643	2560	465	788
Bancroft			4814							
Baronesse	4400	6360	5919	2899	2140	2100	2853	3046	448	724
Meltan	4620			2571			2524	2657	464	774
Mentor		6020	5382				2480	2663	442	943
Tango			3836							
Valier			4852							
Xena			5967						401	937
Camelot	3680	6240		2635		2140				
Camas			5641							
Gallatin	3360	5720	5045	2679	2120	2000	2567	2529		
WA9504-94		6500					2654	2839		
Chinook				2635		2140				
WA 7114-93				2475	2240	2280				
WA 8772-93				2514						
WA 8394-93				2509	2020	2100				
Pongo			5699		1920	2100				
Farmington			5248						416	792
Tofta	4400	6060			2000	2100	2649	2780	464	931
Tena		5680						2516		
Moxex			4368							
Orca			4800							
98NZ015			5235							
98NZ223			5629							
Average	3943	5938	5204	2611	2073	2102	2624	2699	443	841

DEVELOPMENT OF A FIELD TEST TO SCREEN SPRING CEREALS FOR RESISTANCE TO RHIZOCTONIA ROOT ROT AND OTHER GREEN BRIDGE HAZARDS

R. James Cook, Kimberly Kidwell, and Steve Ullrich

Spring cereals seeded directly (no-till) into standing cereal stubble are particularly vulnerable to Rhizoctonia root rot if or when the green bridge (volunteer cereals and weeds) is not eliminated well in advance of planting. The ideal green bridge management for spring cereals is to spray in the fall, just before onset of winter, but this is not possible in years when fall rains come late and volunteer does not begin to grow until late winter or early spring. Likewise waiting the recommended 10 days to 2 weeks and preferably 1 month between spraying and direct seeding in the spring is not practical in years when volunteer green-up and time to seed come more or less at the same time. Recognition of the importance of timely and effective green bridge management represents possibly the single most significant advancement for direct-seed systems, but is also among the single greatest challenges for growers if the weather does not cooperate.

To address this problem, we are experimenting with a field test designed to screen cereals for resistance or tolerance to the hazards created by the green bridge, with emphasis on finding useful resistance or tolerance to Rhizoctonia root rot. One site was started on Spillman Farm for the 1999/2000 crop year and was used for part of the thesis research of M.S. students Jaya Smith, working with spring wheat, and Carolyn Wesselius, working with spring barley. A second test site was initiated on the Palouse Conservation Field Station in 2001/2002. Both sites will be available for use in either alternate years or every year, as needed.

The test uses alternating 8-foot-wide strips of "high" and "low" disease pressure produced, respectively, by poor and good green bridge management (Fig. 1, Step I). "High" disease pressure was achieved starting in the fall of 1999 on the Spillman site using a combination of a) fall-sown winter wheat, to produce a uniform greenbridge; b) inoculum of *Rhizoctonia. solani* AG8 as colonized oat grains placed in the seed furrows with the winter wheat planted the previous fall, to initiate disease; and c) delayed spraying with glyphosate (Round-up) the following spring to within a few days of direct seeding. "Low" disease pressure represented early and effective control of natural volunteer cereals with Round-up and no introduced inoculum of *R. solani* AG8.

After a test with spring cereals in 2000 on green bridge strips initiated in the fall of 1999, the same high disease-pressure strips on the Spillman Farm site were planted again to winter wheat in the fall of 2000 for tests with both spring wheat and spring barley in 2001. The entire Spillman test site had been direct seeded to spring wheat for two years prior to starting the experiment, and therefore the tests in 1999 and 2000 represented the 3rd and 4th years of direct seeded (no-till) cereals on this site. Fertilizer as a liquid mixture of solution 32 (source of nitrogen), phosphorus, and sulfur as thiosul (NPS) was placed directly beneath the winter wheat seed at the time of fall planting the winter wheat green bridge in both 1999 and 2000. For low disease pressure (good green bridge control), the fall-planted and fertilized strips were alternated with 8-foot-wide strips with the same rate of fall-applied fertilizer, but no winter wheat or inoculum of the pathogen. In addition, Round-up was applied to the low disease-pressure (good greenbridge control) strips approximately 1 month before planting the spring cereals in 1999 and 2000, respectively. The entire plot site, including the high disease-pressure strips was then treated with Round-up approximately 1 week before planting. Thus, the entire site was fall-fertilized, but provided alternating levels of poor and good green bridge control.

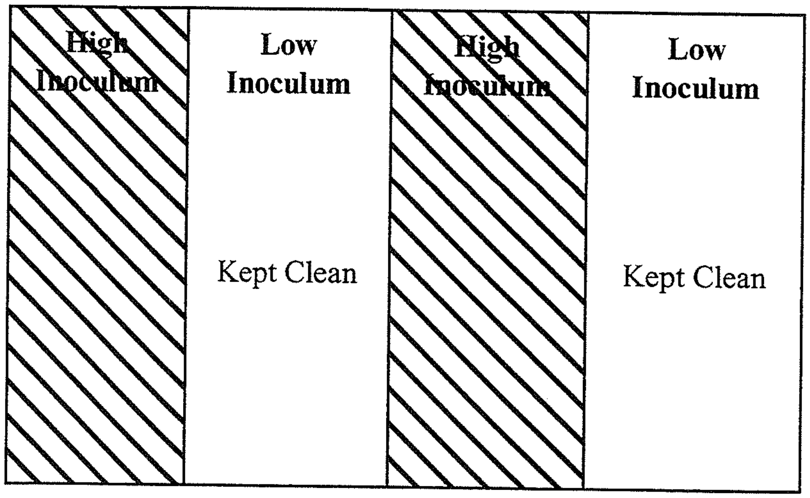
To screen varieties and advanced lines, each genotype of spring wheat and spring barley included in a given test is planted as 8-row plots, with 4-row plots positioned on a high disease-pressure strip and the 4 rows positioned on the adjacent low disease-pressure strip (Fig. 2, Step II). Starter fertilizer is deep-banded at the time of planting in the spring. Thereafter, the paired plots imposed side-by-side on high and low disease-pressure strips are monitored for differences in plant growth, development and yield. The objective is to find genotypes that perform equally well whether exposed to high or low disease pressure.

The high disease-pressure treatments have consistently resulted in significantly more roots with Rhizoctonia root rot than in the low disease-pressure treatments. On the other hand, no "bare patches," typical of severe Rhizoctonia root rot, were evident in either the spring wheat or spring barley tests in either year of the test conducted on Spillman Farm. This indicates that even the high disease-pressure treatments represent the chronic and not the acute form of Rhizoctonia root rot. As a general rule, measurements such as plant height, number of tillers, density of heads, and final yield under high disease pressure have averaged about 90% of the height, tillering, density of heads, and final yields averaged across all genotypes under low disease-pressure, and number (density) of tillers with heads has been negatively correlated with the percentage of diseased roots. The 10% lower average yield with high compared with low disease-pressure has amounted to 8-10 bu/A lower yield for spring wheat and 500-600 lbs/A lower yield for spring barley. While considered "mild" for purposes of the screening test, imposed on a commercial crop, these lower yields would amount to $30-50 less income per acre, depending on the market price of the wheat or barley.

The modest level of disease pressure produced in the "high" treatment should increase the chances of finding subtle but useful differences in ability of wheat or barley lines to resist, tolerate, escape, or outgrow Rhizoctonia root rot. Moreover, because the high disease-pressure treatments are created by deliberately creating a green bridge, this test should also serve to pick up differences in ability of genotypes to produce well when exposed to what ever other hazards may develop in response to inadequate green bridge management. The tests also allow for comparisons over the entire growing season, which should further help to distinguish among genotypes. Both the spring wheat and spring barley tests conducted to date indicate that genotypes exist with ability to grow and yield similarly, e.g., there is no statistically significant difference in yield, whether exposed to high or low disease pressure. These genotypes will be tested again. Other lines included in these tests have performed very poorly with high compared with low disease pressure.

Fig. 1. Rhizoctonia test plot layout on Spillman Farm

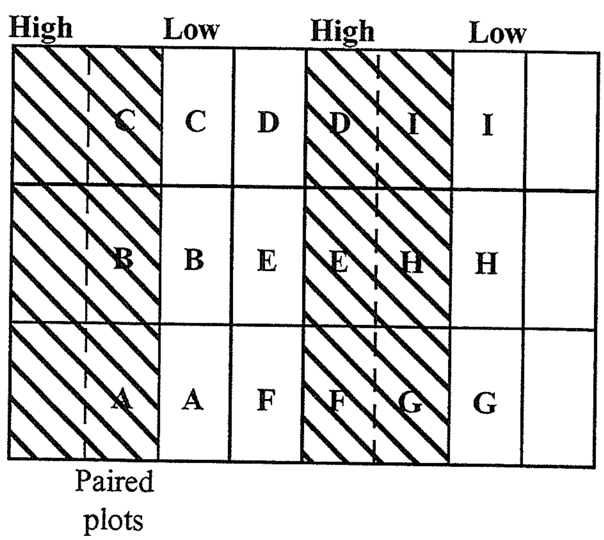
Step I - Two levels of green bridge



- Fall-sown winter wheat
  +
- Rhizoctonia
- Late spring spray

- Fall-sown winter wheat
  +
- Rhizoctonia
- Late spring spray

Step II - Plant



FERTILITY MANAGEMENT OF NO-TILL DRYLAND CORN PRODUCTION

M. K. Bodley, W. L. Pan, G.J. Schwab, F.L. Young, E.D. Harwood, R.P. Bolton

Collaborator: John Aeschliman

There is increasing interest in evaluating corn as an alternative crop in no-till systems in eastern Washington. The establishment of corn as a viable alternative crop to include in rotations could provide a way for growers to break disease and weed cycles while maintaining profits. Fertility management of no-till corn has been tailored to Midwest and Southern U.S. conditions, where summer rainfall is dominant. The semi-arid climate of eastern Washington, with dominant winter rainfall and dry summers, likely requires different fertility management practices. Nitrogen applied at planting may not receive sufficient precipitation to move it to the root zone. In addition, requirements of P, S, and Zn may be different for corn grown in Washington. Growers need a management plan that will help them use their resources effectively to optimize yields while reducing environmental impacts.

The objectives of the project are to determine the optimal rate and timing of nitrogen applications and other nutrient needs for no-till semi-arid corn production in eastern Washington.

The experiment is being conducted in the high (20-24 inches) and intermediate (16-20 inches) rainfall zones of eastern Washington. Pioneer variety 39K72 was direct seeded into standing wheat stubble in May 2002. Four rates of N were applied, ranging from 14 to 159 lb N/acre applied 1) all in the spring, 2) 59 lb N/acre applied in fall and the balance applied in the spring. Additional plots were included to evaluate responses to Zn, S and P. Fall fertilizer was applied with a spoke-wheel injector and spring fertilizer was banded with the seed. Whole plant dry matter and nutrient content are being determined at vegetative, silking, and mid-ear development stages. Fall, spring and post-harvest soil samples are being taken to monitor N movement over the season. Data will be analyzed to begin to formulate best nutrient management practices for no-till corn in eastern Washington.

CARBON AND NITROGEN CYCLING IN DIRECT-SEEDED SPRING CEREAL ALTERNATIVES TO SUMMER FALLOW: SOIL FERTILITY RESEARCH IN THE RALSTON PROJECT

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(adapted from Pan, W.L., F.L. Young, and K.K. Kidwell. 2001. Proceedings of the Western Nutrient Management Conference 4: 202-209. Potash and Phosphate Inst., Brookings, SD.)

Winter wheat alternating with summer fallow is a traditional cropping system in areas where there has been insufficient precipitation for successive annual crops. No-tilled continuous spring cropping can improve water use efficiency, provide alternative pest management strategies and minimize soil erodiblity. Our objectives were to (i) to determine the inputs of plant nutrients required to achieve economic yields and quality in alternative spring crop rotations in the intermediate rainfall zone of eastern Washington, and (ii) to compare the N cycling and relative N use efficiencies among the cropping systems. Farm scale, replicated plots were established to compare soft white winter wheat–conventional fallow (SWW-F), continuous no-till hard red spring wheat (cont. NT HRS), no-till hard red spring wheat–spring barley (NT HRS-SB), and no-till soft white spring wheat–chemical fallow (SWS-CF). Soils were sampled to 6-ft depths to monitor N movement. Continuous no-till spring cropping increased cumulative grain and straw production over the two-year cycle compared to the fallow-based rotations. However, increased N inputs in continuous spring crop rotations resulted in lower recovery of N fertilizer equivalents in the grain compared to SWW-F. Fall N fertilization enhances N availability in the 2nd and 3rd ft of the root profile, optimizing N uptake to achieve grain >14% grain protein goals for hard red spring wheat production. No-tilled continuous spring cropping increased C sequestration compared to fallow-based rotations over a four year period, which was correlated to increased straw C and N production.

Table 1. Grain yield and protein of each crop from 1996 through 2000.

	Year									
	1996		1997		1998		1999		2000	
Crop	Yield bu/A	Protein %	Yield bu/A	Protein %	Yield bu/A	Protein %	Yield bu/A	Protein %	Yield bu/A	Protein %
SWW (F)	70.1	9.7	57.9	13.4	65.1	9.1	52.1	11.8	66.1	8.6
SWS (CF)	45.8	13.7	54.5	10.0	55.3	11.4	34.6	13.5	45.4	11.0
Cont HRS	35.9	16.1	49.7	13.2	34.8	17.8	29.2	16.4	30.2	16.9
HRS (SB)	38.4	17.1	50.0	12.9	37.7	17.4	33.0	16.5	34.9	15.4
SB (HRS)	39.6	9.4	69.3	8.7	60.1	11.7	36.2	12.5	54.1	14.3

*Annual grain yields and protein for the SWW and SWS were obtained in opposing two-year rotations with fallow, whereas annual HRS and SB yields and protein were obtained in two-year rotations with sequential spring cropping.

Table 2. Four-year (1997-2000) accumulation of biomass and C, N, S in grain and straw of each rotation: soft white winter wheat–fallow (SWW-F), no-till soft white spring wheat–chemical fallow (SWS-CF), continuous hard red spring wheat (HRS), and hard red spring wheat–spring barley (HRS-SB).

Rotation	Grain yield	Grain C	Grain N	Grain S	Straw yield	Straw C	Straw N	Straw S
	---------------	---------------	---------------	---lb/A/4 years---	---------------	---------------	---------------	
SWW-F	7237 d	3207 c	134.5 b	10.3 b	9501 b	4288 b	41.3 c	8.1 c
SWS-CF	5694 c	2534 d	112.4 c	9.6 b	5639 c	2490 c	25.5 d	4.5 d
NT HRS	8630 b	3861 b	237.9 a	19.9 a	11839 a	5313 a	86.9 a	16.0 a
HRS-SB	9067 a	4040 a	225.4 a	19.1 a	11594 a	5180 a	75.0 b	14.5 b

POST-HARVEST MANAGEMENT OF RUSSIAN THISTLE

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Russian thistle (*Salsola iberica* Sennen and Pau) is the most problematic broadleaf weed in wheat in the low-rainfall (less than 12 inch annual) dryland region of the inland Pacific Northwest. At the request of the Benton County Wheat Growers Association, we have designed an experiment to test long-term post-harvest management on the control and ecology of Russian thistle. Benton County growers have two fundamental questions. Question 1: Given the high Russian thistle seed density throughout the low-rainfall dryland region, does it even pay to control Russian thistles after harvest? Question 2: Using a V-shape sweep for post-harvest control of Russian thistle is less expensive than herbicides, but is over-winter water storage greater when sweeping is not conducted?

Our study at the Lind Dryland Research Station compares three post-harvest Russian thistle control treatments in continuous soft white spring wheat. These treatments are:

1. Surefire herbicide (paraquat + diuron) at 24 ounces/acre applied 10 days after wheat harvest.
2. Tillage with overlapping adjustable-pitch 32-inch-wide V-blade sweeps on 28-inch centers conducted 10 days after wheat harvest.
3. Check (do nothing, let the Russian thistles grow).

Measurements are: Soil water to a depth of six feet at wheat harvest, after killing frost in the fall, and again in early spring; above-ground Russian thistle dry matter, seed production, and germination at wheat harvest and after killing frost in the fall; and wheat grain yield. Experimental design is a randomized complete block with four replications.

We completed the third year of this study in 2001. Controlling Russian thistle after harvest either mechanically with wide-blade sweeps or with herbicide significantly reduced Russian thistle soil water use, dry matter production (2 years), and seed production, resulting in subsequent higher grain yield (1 year) compared with the uncontrolled check treatment (Table 1). The soil was so dry after harvest in August 2001 due to drought and three years of continuous wheat that Russian thistle plants produced little post-harvest dry matter, but the check treatment still produced seed (Table 1). We plan to continue this study for at least two more years and then report the detailed results in both scientific and popular journals.

Table 1. Soil water dynamics, Russian thistle growth and seed production, and subsequent spring wheat grain yield as affected by method of post-harvest Russian thistle control during three years at Lind, Washington.

Crop Year	Post-harvest control method	Soil Water (inches)			Russian Thistle				Grain yield (bu./ac.)
		After harvest	After frost	Early spring	After harvest biomass (g/ m^2)	After frost biomass (g/ m^2)	Seeds (per m^2)	Germination (%)	
1999-2000	Check	2.76	2.37 b	4.91	---	402 a	---	---	17.2
	Spray	3.09	3.06 a	5.04	---	155 b	---	---	21.5
	Tilllage	3.06	3.06 a	4.90	---	131 b	---	---	19.0
2000-2001	Check	2.35 b	2.50 b	3.32 b	77 a	135 a	8857	56.0	2.8 b
	Spray	3.40 a	3.20 a	3.20 b	32 ab	7 b	0	---	7.8 a
	Tillage	3.66 a	3.16 a	4.50 a	21 b	5 b	0	---	12.0 a
2001-2002	Check	2.83 ab	2.28 b	---	161	174	1548	76.7	---
	Spray	2.52 b	2.30 b	---	243	189	148	55.2	---
	Tillage	2.98 a	2.97 a	---	244	180	0	---	---

RUSSIAN THISTLE CONTROL WITH SOIL-ACTIVE HERBICIDES

Joe Yenish, Extension Weed Specialist

Russian thistle (*Salsola iberica*) is a plant species that is a major stumbling block for the adoption of intensive direct-seed cropping systems in eastern Washington. Uncontrolled, this weed depletes soil moisture, reduces yield of spring wheat, and makes harvest difficult. However, there is hope to control Russian thistle through the use of soil applied herbicides as part of an integrated management program. Research is being conducted at Washington State University to evaluate two herbicides for their control of Russian thistle and to determine their greatest utility in current and proposed rotations. Applications of these herbicides may prevent yield and quality loss in a spring wheat crop and eliminate the need to control Russian thistle with herbicides or by mechanical undercutting during the post-harvest period.

Spartan® from FMC Corporation has recently been labeled for use in fallow systems for control of several broadleaf weeds. Previous research at WSU has shown that this herbicide provides good to excellent control of Russian thistle when applied in the fall or spring prior to planting spring wheat. According to its label, Spartan® may be applied alone or in combination with other herbicides for residual control of broadleaf weeds in the post-harvest burndown/fallow period of late summer, fall, or early spring prior to planting of labeled or rotational crops. In more practical terms, this means that Spartan® may be tank-mixed with burndown herbicides such as RoundUp® to control Russian thistle present at the time of application and prevent emergence of additional Russian thistle plants in the months following application. Applications of Spartan® must be made at least 4 months prior to planting wheat, barley, oats, or triticale. Labeled rates of 2.0 to 5.33 oz Spartan®/A (0.094 to 0.25 lbs. of the active ingredient sulfentrazone/A) may be applied in fallow. WSU research is now focusing on the finding the optimal herbicide rate for applications made in the fall prior to spring planting. Good to excellent control of Russian thistle has been seen with applications as low as 2.0 oz. Spartan®/A when applied 2 weeks prior to spring wheat planting, but it is expected a greater herbicide rate will be needed when applied 4 months prior to planting. Currently, discussions are underway with the Washington Wheat Commission, WSU, and FMC Corporation to conduct research that would allow Spartan® applications closer to spring wheat planting or even following planting. An estimated range of herbicide cost using 2001 approximate herbicide prices provided by North Dakota State University ranges from $5.00 to $13.35/A for 2.0 to 5.33 oz Spartan®/A.

Another product labeled for control of Russian thistle in spring wheat is Valor Herbicide™ from Valent U.S.A. Corp. Valor is labeled for use as part of an early preplant burndown program for wheat when applied greater than 30 days prior to planting. Valor Herbicide™ may be used at up to 2.0 oz of product (0.0625 lbs. of the active ingredient flumioxazin/A) at this timing. WSU and others are currently researching the efficacy of this herbicide at varying rates and timings for Russian thistle control in wheat and other crops. An estimated range of herbicide cost using 2001 approximate herbicide prices provided by North Dakota State University is $9.00/A for the 2.0 Valor Herbicide™ /A rate.

In summary, it is possible to effectively control Russian thistle in fallow and crop. Work at WSU and elsewhere will continue to evaluate the best method to integrate two new herbicides, Spartan® and Valor™, into a management program for Russian thistle in direct-seed systems.

PRESERVING SALMON HABITAT WITH CONSERVATION TILLAGE: AN ECONOMIC ANALYSIS

Jason Monson, Holly Wang, and Herb Hinman[1]

The decline in the number of salmon in the Pacific Northwest (PNW) has become a key ecological concern in the area. Sixteen salmon species have been listed as endangered or threatened under the Endangered Species Act. Restoring salmon habitat is a primary issue in saving salmon from extinction. Sediments from agriculture in rivers and streams can destroy salmon habitat by filling in spawning pools, reducing habitat for food sources and carrying harmful chemicals. A three-year study is being conducted in the Pataha watershed to determine, improve, and promote practices for dryland agriculture that enhances water quality for salmon.

The adoption of conservation tillage by PNW dryland grain growers is behind other regions in the U.S. Many farmers are skeptical whether it can be at least as profitable as conventional tillage, especially during the transition period. The varying climate, soils and hilly topography of the PNW impose challenges and additional costs to production practices. The objective of this study is to determine the economic feasibility of adopting conservation tillage by comparing the change in profitability from a conventional tillage system.

A case study was conducted to investigate the benefits and costs of conventional tillage versus direct seeding systems in the Pataha watershed. This watershed is located in the southeastern corner of Washington State, and cereal crops are produced under dryland agriculture. The region receives an annual average 18 inches of rainfall with most of precipitation during the fall and winter. Snow melt from the adjacent Blue Mountains and surface runoff from agriculture and forest land flow into Pataha Creek, which flows throughout the watershed.

Farmers who practice conservation tillage in Garfield County, which encompasses the Pataha watershed, were selected. These growers have several successive years of direct seeding experience with successes and failures. Two growers were interviewed to determine their cropping practices, culture practices, input prices, yields, and machinery complement. The costs of renting the no-till drills were used to approximate variable and fixed costs of this machinery. For the conventional cropping system a minimum machinery complement was constructed based upon the amount needed to perform the operations in a prudent time period.

From this information enterprise budgets were constructed with the Washington State University Farm Enterprise Budget Simulator. Total revenue was determined from yields provided by the producers or average yields for Garfield County in the case of the conventional tillage system. These yields were multiplied by the average August Portland, Oregon cash price from 1996 to 2001. The seven-year August average price for U.S. number two barley with a test weight of 48 pounds or above is $99.95 per ton. The seven-year August average price for U.S. number one soft white is $3.68 per bushel. Government subsidies from CRP or the market transition programs were not considered, because they do not influence the tillage system chosen.

[1] The authors are, respectively, Graduate Research Assistant, Assistant Professor, and Professor in the Department of Agricultural and Resource Economics, Washington State University.

Conventional Cropping System
The conventional crop rotation for this area is winter wheat followed by spring barley, and then the land is fallowed a year before planting the next winter wheat crop. Wheat stubble in the fall is tilled with a disc, chisel, or both. The remaining residue is left to decompose through the winter. In the spring the worked wheat stubble is sprayed with Roundup® to control emerging weeds. Following this the ground is cultivated, fertilized (80 lbs. N, 12 lbs. S) and seeded (80 lbs./acre) to two-row spring barley in March or April with conventional double disc drills. Spring barley stubble will be sprayed with Roundup® in the spring and then chiseled or disced. It will then be rodweeded as needed throughout the summer. In September or October, the fallow will be fertilized (60-80 lbs./ acre) and seeded to soft white winter wheat. The average winter wheat yield for Garfield County is 70 bushels per acre, and the average spring barley yield is 1.75 tons per acre.

Two-Pass Direct Seeding System
Farmer A uses a continuous cropping rotation of soft white winter wheat followed by soft white spring wheat. Beginning in the spring the winter wheat stubble is sprayed with Roundup® to kill all vegetation. Then a two-pass direct seed system is used. First, the stubble is worked with a Calkin's chisel plow and aqua (20-0-0) is applied with this operation (80 lbs. N, 12 lbs. S/acre). Next, soft white spring wheat is seeded (85 lbs./acre) with a Krause 5300 no-till drill, and the liquid fertilizer Solution 32 (32-0-0) is applied as starter with the drill (9 N lbs./ acre). Following harvest Farmer A works the spring wheat stubble with a Calkin's chisel plow that fertilizes with aqua (80 lbs. N, 12 lbs. S). If there is vegetative growth Roundup® is sprayed prior to seeding the stubble with soft white winter wheat (75 lbs./acre) with a Krause 5300 no-till drill. Annual broadleaf weeds are controlled in the spring with Harmony GT, and wild oats with Puma. This producer has an average spring wheat yield of 38 bushels per acre and an average winter wheat yield of 54 bushels per acre.

Three-Year Direct Seeding System
Farmer B's cropping rotation consists of spring barley, soft white spring wheat, and soft white winter wheat. Beginning in the spring the winter wheat and spring barley stubble is sprayed with Roundup® to kill all vegetation. Next, soft white spring wheat (65 lbs./acre) is seeded into spring barley stubble and spring barley (65 lbs./acre) is seeded into winter wheat stubble with a John Deere 750 no-till drill. Following harvest Farmer A sprays the spring wheat stubble if there is vegetative growth with Roundup®. Next, the winter wheat is seeded into spring wheat stubble (65 lbs./acre) with a John Deere 750 no-till drill. Dry fertilizer 11-52-0 (30 lbs./acre) is applied with the drill with both the spring and fall plantings. Also, aqua (20-0-0) is applied with the drill (80 lbs. N, 12 lbs. S/ acre). Farmer B uses the same procedures and pesticides to control annual broadleaf weeds. This producer has an average spring wheat yield and winter wheat yield of 52 bushels per acre, and the average spring barley yield is 1.66 tons per acre.

Economic Costs
Assuming a total of 1,500 acres equally divided among winter wheat, spring barley, and fallow, conventional dryland farming had the following total economic cost per acre: winter wheat $228.43, spring barley $181.21, and summer fallow $79.75. Farmer A is assumed to seed 750 acres of spring wheat and 750 acres of winter wheat annually. His total economic cost per acre for winter wheat was $189.59 and for spring wheat $176.34. Producer B is assumed to annually

seed 500 acres of winter what, spring wheat and spring barley. He had the lowest total economic cost per acre for winter wheat $159.84, spring barley $177.42, and spring wheat $186.37.

Profitability

Farmer B produces winter wheat most profitably with a profit of $31.52/ acre, which is $2.35/ acre more than the conventional tillage system. Spring barley is more profitable under the conventional system with a loss of $6.30 compared to Farmer B with $11.50/acre. Even with lower yields, Farmer B still has higher overall profit than the conventional system. The main reason is cropping intensification, because summer fallow generates zero revenue while incurring costs. Eliminating fallow is made possible by reduced tillage, which keeps more moisture in the soil than conventional tillage. Also, eliminating fallow significantly reduces soil erosion and contributes to better water quality for salmon preservation. Net returns per rotational acre for the conventional system, Farmer A, Farmer B are: ($18.96), ($13.69), and $5.18 respectively, before receiving the government program payments (Table 1).

Table 1: 2001 Pataha Watershed Profit Comparison of Production Systems Based on 1500-Acre Farms For Each Scenario with Acres Divided Equally Among the Rotations, in an 18" Rainfall

	Revenue/ Acre	Variable Cost/ Acre	Fixed Cost/ Acre	Total Cost/ Acre	Profit/ Acre	Breakeven Yield (Bu/Acre)	Breakeven Price
Conventional System							
Winter Wheat	$257.60	$59.83	$168.60	**$228.43**	**$29.17**	62.07	$3.26
Spring Barley	$174.91	$117.31	$63.90	**$181.21**	**($6.30)**	1.81	$103.55
Summer Fallow	$0	$61.45	$18.30	**$79.75**	**(79.75)**	N/A	N/A
2- Year Direct Seed Rotation (Farmer A)							
Winter Wheat	$198.72	$118.99	$70.60	**$189.59**	**$9.13**	51.52	$3.51
Spring Wheat	$139.84	$125.94	$50.40	**$176.34**	**($36.50)**	47.92	$4.64
3- Year Direct Seed Rotation (Farmer B)							
Winter Wheat	$191.36	$98.25	$61.59	**$159.84**	**$31.52**	43.44	$3.07
Spring Barley	$165.92	$128.70	$48.72	**$177.42**	**($11.50)**	1.78	$106.88
Spring Wheat	$191.36	$124.01	$62.36	**$186.37**	**$4.99**	50.64	$3.58

Breakeven Analysis

Breakeven analysis confirms that Farmer B, with a three-year direct seeding rotation is a low cost producer of winter wheat. Farmer B has a breakeven yield of 43.43 bushels/acre and a breakeven price of $3.07/bushel. The conventional system requires a wheat yield of 62.07 bushels/acre and a price of $3.26/ bushel, and Farmer A 51.52 bushels/ acre and $3.51/ bushel respectively. The difference in the two direct seeding systems is the significantly higher cost of $29.75/acre that Farmer A incurs in producing winter wheat. Also, conventional tillage has a higher breakeven due to higher costs, and harvesting a winter wheat every biennium. Under direct seeding an average 52 bushels/acre of winter wheat are harvested every year, whereas with the conventional system 70 bushels/acre are harvested every biennium. Finally, similar breakeven yields and prices are required with spring barley under the conventional system and the three-year direct seed rotation, 1.8 ton/acre, 1.775 ton/acre, and $103.55/ton, $106.88/ton respectively. This is due to comparable costs and yields of producing barley between the systems.

Sensitivity Analysis

Sensitivity analysis was performed to observe the variability in profitability as yields change. The profit of each system is similarly sensitive to the change in yields as shown by the parallel profits line in Figure 1 and 2. However, both direct seeding systems return a positive dollar profit before the conventional tillage system for winter wheat. If the yield of winter wheat drops to 30 bushels/acre, the loss will be about $50, $80, and $120 per acre for Farmer B, Farmer A and the conventional farmer, respectively. Likewise, if yields increase to 100 bushels/acre, their profits will reach $210, $180, and $140 per acre (Figure 1).

Figure 1: Sensitivity Analysis of Winter Wheat Profit per Acre, Price is $3.68/Bushel

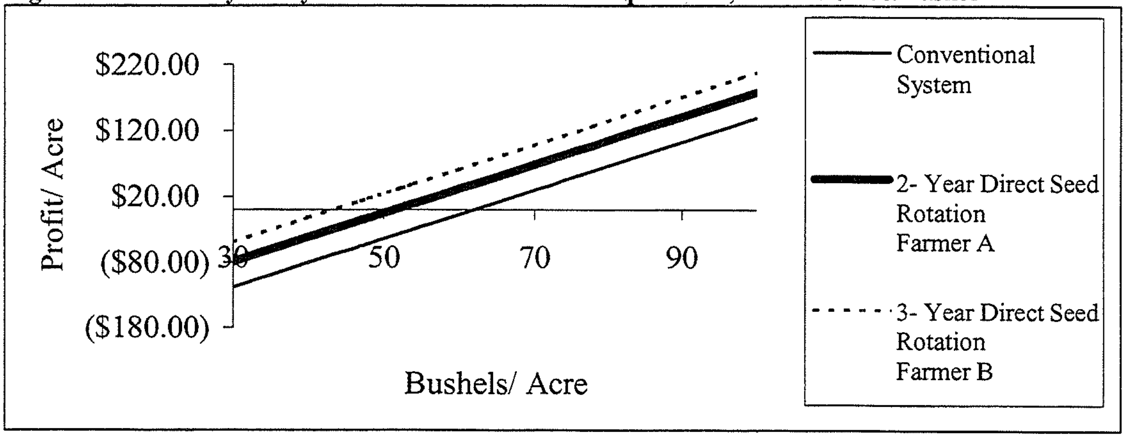
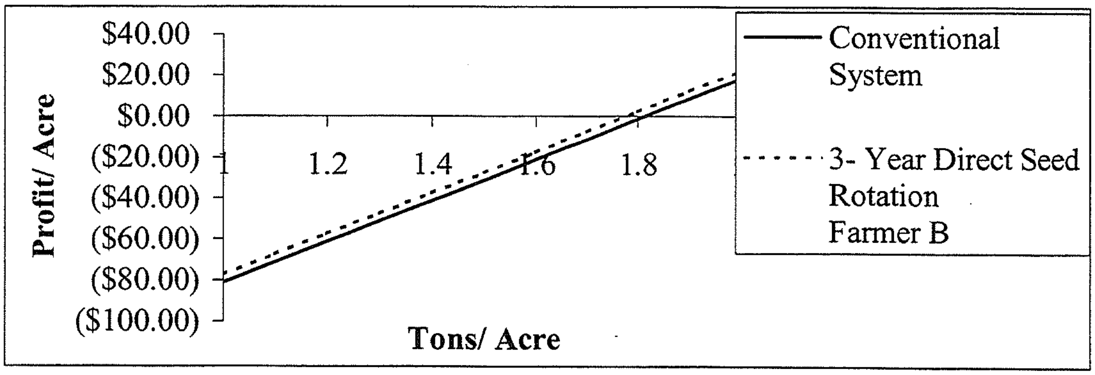


Figure 2: Sensitivity Analysis of Spring Barley Profit per Acre, Price is $99.95/Ton



Conclusions

The primary goal of the study was to promote the use of conservation tillage practice and reduce soil erosion. Soil sediments and agriculture pollutants reduce the quality of stream water for salmon spawning. In recent years the salmon numbers have been declining, so maintaining healthy and diverse salmon species has become an important priority of society.

Economic budgets were calculated to determine the profitability of each commodity under the different production techniques. The three-year direct seed rotation of Farmer B was determined to be the most profitable, followed by the two-year direct seed rotation of Farmer A, and conventional tillage system. From these case studies and under similar culture practices, weather conditions, and soils there is additional revenue earned from reduced tillage. Finally, society obtains a social benefit from reduced soil erosion into waterways and enhanced stream habitat for salmon spawning.

ECONOMICALLY OPTIMAL NITROGEN FERTILIZATION OF HRSW FOR YIELD AND PROTEIN

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The price that a producer receives for hard red spring wheat (HRSW), unlike soft white wheat (SWW), is influenced by protein content (%). The producer receives a premium on wheat with greater that 14% grain protein and a discount on wheat with less that 14% grain protein. Since both yield and protein percentage directly affect profit, producers may desire to apply levels of Nitrogen (N) fertilizer to HRSW that maximize profits considering both yield and protein. Several factors affect yield and protein levels including growing season precipitation, pre-plant soil moisture, residual soil NO_3, and applied N. While pre-plant soil moisture and residual soil NO_3 is measurable, growing season precipitation is beyond the dryland farmer's control. Research has shown there are significant relationships between N fertilization levels, grain yield, and protein content (Terman, et al., 1969). With these factors in consideration, the producer would like to choose a level of N fertilization to maximize profit (returns over N costs).

Material and Methods

HRSW field experiment data consisting of rates of N fertilization (lb/ac), grain yield (bu/ac), and grain protein (%) were used to estimate regression models to predict yield and protein in response to N. Field experiments were randomized complete block designs over two growing seasons, 1987-1988 and 1988-1989, near Pullman, WA (21.5 in. average annual precipitation) (Huggins 1991). The data had not been previously subject to economic analysis. To show the effects of changing economic conditions on optimal N fertilization, the analysis considered high, intermediate, and low grain prices, and five premium/discount (P/D) structures. The range of P/D structures were based on ten years of historical Port of Portland price data (USDA, Grain Market News 2001). Premiums and discounts are in cents/bu per ¼ percent above or below 14% protein. The base grain prices are adjusted to reflect transportation costs from eastern Washington. High and low nitrogen fertilizer prices were based on annual average high and low prices paid by Northwest Region farmers for anhydrous ammonia in the years 1997 to 2001 as reported by Washington Agricultural Statistics Service. (WASS 2001)

Regression was used to determine the statistical relationships between yield and N and protein and N. Sufficient data were not available from the experiments to include the effects of spring soil nitrate or soil moisture on yield and protein. Estimated yield and protein models were integrated into a profit ($/ac) function conditional on grain price, N price, and P/D structure. Iterative use of a spreadsheet with the profit function identified the N rate, which maximized profit for selected HRSW prices, protein P/D structures, and N prices. The analysis also identified the wheat yield and protein level associated with each profit maximizing profit level.

Results

Tables 1-6 report maximum profits, and corresponding optimal N fertilization levels, protein levels, and yields at five P/D structures for different combinations of HRSW price and N price.

For example in Table 1, wheat price is $5.20/bu., N price is $0.22/lb. At the P/D structure of $0.01/bu premium and $0.03/bu discount per .25% deviation from 14%, profit is maximized at $276.54/ac by fertilizing at 134.8 lb/acre of N, with optimal protein of 13.77% and yield of 59.2 bu/ac. Each line in each table reports the maximum profit corresponding to that P/D structure. The comparisons between the tables are interesting as they show changes in optimal N fertilization and maximum profit for different wheat and N price combinations. Comparisons within tables reveal changes in N fertilization and maximum profit for different P/D structures.

Decreasing wheat price given a low N price (Tables 1-3) resulted in little change in optimal N levels at low P/D's, but increases N at higher P/D's as more profit can be made by fertilizing to increase protein. Reducing wheat price given a high N price (Tables 4-6) results in decreases in optimal N applied at low P/D's and increases at higher P/D's. However the increase in N is less than that with low N prices due to the increased cost of N.

Increasing N price at all wheat prices (Tables 1 & 4; 2 & 5; 3 & 6) resulted in a decrease in optimal N levels and optimal protein levels at both low and high P/D's. Increasing N price resulted in reduced profits in each scenario. Optimal yield varied little with changes in both N and wheat price. Wheat price is the dominant factor in changing profits. Decreasing wheat prices from $5.20/bu to $3.80/bu (Table 1 to 3) reduced profits approximately $82/acre across all P/D's. Increasing N prices from $0.22/lb to $0.32/lb (Table 1 to 4) reduced profits approximately $13 to $16/acre with variation by both P/D's, and wheat prices.

Within any wheat price and N price combination (Tables 1-6) significant change on optimal N fertilization levels occurred with changes in P/D structures. For example in Table 4 moving from a $0.03 discount to a $0.06 discount results in an increase in optimal N by 10.7 lb/ac, profit was maximized by increasing protein levels to avoid higher discounts. In Table 4 moving from a $0.06 premium to a $0.12 premium resulted in an increase in optimal N by 14.3 lb/ac, profit was maximized by increasing protein levels to capture higher premiums.

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PROFIT MAXIMIZATION TABLES 1-6

(Optimal Nitrogen Fertilization Rates and Resulting Grain Protein and Yield, by Varying Wheat Prices, Protein Premiums & Discounts, & Nitrogen Input Prices.)

Table 1. High Price Wheat, Low Price N

N Price $/lb = $0.22			Wheat Price $/bu (14% Pro) = $5.20		
Prem. $/bu	Disc. $/bu	Optimal N lb/ac	Maximum Profit $/ac	Optimal Protein %	Optimal Yield bu/ac
$0.01	$0.03	134.8	*$276.54*	13.77	59.2
$0.04	$0.06	143.8	*$275.87*	13.99	59.2
$0.06	$0.09	145.6	*$275.90*	14.04	59.1
$0.08	$0.12	151.8	*$276.45*	14.19	58.9
$0.12	$0.20	163.4	*$279.73*	14.48	58.1

Table 2. Intermediate Price Wheat, Low Price N

N Price $/lb = $0.22			Wheat Price $/bu (14% Pro) = $4.50		
Prem. $/bu	Disc. $/bu	Optimal N lb/ac	Maximum Profit $/ac	Optimal Protein %	Optimal Yield bu/ac
$0.01	$0.03	134.8	*$235.11*	13.77	59.2
$0.04	$0.06	143.8	*$234.46*	13.99	59.2
$0.06	$0.09	146.5	*$234.53*	14.06	59.1
$0.08	$0.12	153.6	*$235.27*	14.24	58.8
$0.12	$0.20	167	*$239.19*	14.57	57.8

Table 3. Low Price Wheat, Low Price N

N Price $/lb = $0.22			Wheat Price $/bu (14% Pro) = $3.80		
Prem. $/bu	Disc. $/bu	Optimal N lb/ac	Maximum Profit $/ac	Optimal Protein %	Optimal Yield bu/ac
$0.01	$0.03	134	*$193.67*	13.75	59.2
$0.04	$0.06	143.8	*$193.06*	13.99	59.2
$0.06	$0.09	147.3	*$193.18*	14.08	59.1
$0.08	$0.12	156.3	*$194.18*	14.30	58.6
$0.12	$0.20	171.5	*$198.91*	14.68	57.3

Table 4. High Price Wheat, High Price N

N Price $/lb = $0.32			Wheat Price $/bu (14% Pro) = $5.20		
Prem. $/bu	Disc. $/bu	Optimal N lb/ac	Maximum Profit $/ac	Optimal Protein %	Optimal Yield bu/ac
$0.01	$0.03	128.6	*$263.31*	13.62	59.1
$0.04	$0.06	139.3	*$261.63*	13.88	59.2
$0.06	$0.09	144.7	*$261.42*	14.02	59.1
$0.08	$0.12	146.5	*$261.53*	14.06	59.1
$0.12	$0.20	159	*$263.58*	14.37	58.5

Table 5. Intermediate Price Wheat, High Price N

N Price $/lb = $0.32			Wheat Price $/bu (14% Pro) = $4.50		
Prem. $/bu	Disc. $/bu	Optimal N lb/ac	Maximum Profit $/ac	Optimal Protein %	Optimal Yield bu/ac
$0.01	$0.03	127.7	*$221.96*	13.59	59.0
$0.04	$0.06	139.3	*$220.19*	13.88	59.2
$0.06	$0.09	144.7	*$220.03*	14.02	59.1
$0.08	$0.12	147.3	*$220.17*	14.08	59.1
$0.12	$0.20	160.7	*$222.71*	14.41	58.3

Table 6. Low Price Wheat, High Price N

N Price $/lb = $0.32			Wheat Price $/bu (14% Pro) = $3.80		
Prem. $/bu	Disc. $/bu	Optimal N lb/ac	Maximum Profit $/ac	Optimal Protein %	Optimal Yield bu/ac
$0.01	$0.03	125.9	*$180.64*	13.55	59.0
$0.04	$0.06	140.2	*$178.75*	13.90	59.2
$0.06	$0.09	144.7	*$178.63*	14.02	59.1
$0.08	$0.12	149.1	*$178.86*	14.13	59.0
$0.12	$0.20	165.2	*$182.05*	14.53	58.0

ECONOMICS OF ALTERNATIVE NO-TILL SPRING CROPS AT JIRAVA FARM, RITZVILLE, WA

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During 1997-1999, Ron Jirava grew several no-till continuous spring crops at his farm near Ritzville, for which the cost of production was estimated. Table 1 displays the farmer's sale prices and crop yields for safflower, mustard, spring barley (SB), and soft white spring wheat (SWSW). Prices for the grains are marketing year averages for Washington, but those for oilseeds are the farmer's actual prices. The years 1997-1999 were higher moisture than 2000 and 2001. Consequently, the crop yields are probably somewhat higher than could have been expected recently. Jirava did not grow oilseeds in 2000 and 2001.

Table 2 shows that continuous no-till SWSW topped all systems during this three-year period with net returns over total costs of $12.86/acre. Total costs include a return for the operator's labor and land and machinery investment. The other three continuous no-till spring crops incurred small losses of -$3.71 to -$17.87 per acre. The performance of continuous no-till SWSW is impressive, but more data is needed over a broader spectrum of weather to reach conclusions on its long run economic viability. Analysis of an experiment by Bill Schillinger at the same site including three no-till SWSW rotations is reported separately in this bulletin.

Tables 3, 4 and 5 report the effect of yield and price changes on returns over total costs for continuous no-till SWSW, safflower and spring barley. The lightly shaded area in each table shows the combinations of price and yield which generate a positive return over total costs. The darkly shaded area shows net returns for the price and yield combination which is closest to the Ritzville grower's 1997-1999 average. For example, a safflower yield of 822 pounds/acre sold for $0.12/pound generates a net return of -$9.88/ac given the grower's production costs of $108.53/ac (Table 4). Table 3 shows that for a SWSW price of $3.17/bu, the break-even yield will be between 30 and 40 bu/ac for production costs of $116.03/ac. Dividing $116.03 by $3.17 gives the exact break-even yield of 36.6 bu/ac.

Table 1. Annual Prices and Yields by Crop for a Ritzville Grower, 1997-99.

	Safflower		Mustard		Spring Barley		SWSW	
	$/lb	Yield	$/lb	Yield	$/ton	Yield	$/bu	Yield
1997	0.12	711	0.12	964	94.6	0.75	3.61	61
1998	0.12	770	0.12	648	65.84	1	2.90	36
1999	0.12	985	0.12	342	73.3	2.3	3.00	23
Avg.	0.12	822.0	0.12	651.3	77.91	1.350	3.17	40.66

Table 2. Average Revenue, Costs, and Net Returns ($/ac) by Cropping System for a Ritzville Grower, 1997-99.

Rotation	Rev/Ac	Cost/Ac Variable	Cost/Ac Total	Net Returns Over Cost Variable	Net Returns Over Cost Total
SWSW	128.89	55.07	116.03	73.82	12.86
Spring Barley	105.17	55.75	108.88	49.42	-3.71
Safflower	98.64	56.92	108.53	41.72	-9.88
Yellow Mustard	78.16	51.24	96.03	29.63	-17.87

Note: Government payments are excluded.

Table 3. Effect of Yield and Price Changes on ($/rot. Ac) for No-Till SWSW, Ritzville Grower.

			$/bu.		
bu/ac	2.37	2.77	3.17	3.57	3.97
20	-68.63	-60.63	-52.63	-44.63	-36.63
30	-44.93	-32.93	-20.93	-8.93	3.07
41	-19.67	-3.40	12.86	29.13	45.39
50	2.47	22.47	42.47	62.47	82.47
60	26.17	50.17	74.17	98.17	122.17

Note: Assuming total costs/ac =$116.03. Grower's average 1997-99 yield and price were 40.66 bu/ac and $3.17/bu. Government payments are excluded.

Table 4. Effect of Yield and Price Changes on ($/rot. Ac) for No-Till Safflower, Ritzville Grower.

			$/lb.		
lb/ac	0.08	0.1	0.12	0.14	0.16
422	-74.76	-66.32	-57.88	-49.44	-41.00
622	-58.76	-46.32	-33.88	-21.44	-9.00
822	-42.76	-26.32	-9.88	6.56	23.00
1022	-26.76	-6.32	14.12	34.56	55.00
1222	-10.76	13.68	38.12	62.56	87.00

Note: Assuming total costs/ac =$108.53. Grower's average 1997-99 yield and price were 822 lbs/ac and $.12/lb. Government payments are excluded.

Table 5. Effect of Yield and Price Changes on ($/rot. Ac) for No-Till S.Barley, Ritzville Grower.

			$/ton.		
ton/ac	48	63	78	93	108
0.65	-77.72	-67.97	-58.28	-48.47	-38.72
1.00	-60.92	-45.92	-31.01	-15.92	-0.92
1.35	-44.12	-23.87	-3.74	16.63	36.88
1.70	-27.32	-1.82	23.53	49.18	74.68
2.05	-10.52	20.23	50.80	81.73	112.48

Note: Assuming total costs/ac = $108.88. Grower's average 1997-99 yield and price were 1.35 t/ac and $77.91/ton. Government payments are excluded.

ECONOMICS OF NO-TILL ANNUAL SPRING CROPPING SYSTEMS PROJECT, RITZVILLE, WA

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In 1997, Washington State University conducted a no-till annual spring cropping systems project in Adams County, near Ritzville, WA. The objective of this study was to determine the long-run feasibility of diverse, cereal based, no-till cropping systems for low-rainfall areas of the inland Pacific Northwest. Spring crops included yellow mustard (Y.M.), safflower (Saff.), soft white spring wheat (SWSW), and spring barley (S.B.). With these spring crops, researchers maintained three rotations: four-year Saff./Y.M./SWSW/SWSW, two-year S.B./SWSW, and continuous SWSW.

Table 1 shows the yields for each crop per rotation throughout 1997 to 2001. After the fourth year, Saff. was discontinued from the four-year rotation. However, in 2001, the remaining crops of the original 4-year rotation were planted in the original sequence. To permit estimating profitability of the 4-year rotation for 2001, the profit for Saff. was estimated based on its historical relationship with Y.M.. Tables 2 and 3 summarize revenues, costs, and net returns per rotational acre for the three rotations. Continuous SWSW provided the highest net returns at $8.52/ac over five years. This rotation had an intermediate profit risk level over the five years with a standard deviation of $40.39/ac.

Over five years the Saff./Y.M./SWSW/SWSW rotation was the least competitive, with a loss of -$9.43 per rotational acre. With the exception of 1997, this rotation experienced negative net returns. However, Saff./Y.M./SWSW/SWSW had the lowest risk over five years with a standard deviation of $36.06/ac.

In 2001, inadequate soil moisture contributed to poor yields and negative net returns for all rotations. Table 2 shows the drought negatively affected spring barley/SWSW net returns. During 2001, this rotation had the lowest revenues per rotational acre of $34.88. With total costs at $80.88/ac for barley/SWSW, this rotation lost $51.96/ac in 2001 (Table 3). Total costs include all costs including a return for the operator's labor and land and machinery investment. Interestingly, Saff./Y.M./SWSW/SWSW fared the best in the drought year. At -$37.55/ac net returns over total costs in 2001, the oilseed rotation earned $4.60 more than the second best rotation, continuous SWSW. The drought reduced the net returns over all rotations by an average of $10.78/ac. Over 1997-2001, continuous SWSW remained the only profitable rotation with average net returns over total costs of $8.52/ac.

Table 1. Crop Yields from all Rotations, Continuous No-till Spring Cropping Systems Project, Adams County, WA, 1997 - 2001

Rotation		Units	1997	1998	1999	2000	2001	5-yr Avg.
1. Four-Year	Safflower	lb/acre	1420	720	1040	600	702[a]	896[a]
	Yellow Mustard	lb/acre	1430	340	110	490	350	544
	Spring Wheat	bu/acre	63.8	41.0	27.0	40.0	8.0	36.0
	Spring Wheat	bu/acre	57.9	37.1	25.0	38.0	6.0	32.8
2. Two-Year	Spring Wheat	bu/acre	64.8	40.0	28.0	44.0	12.0	37.8
	Spring Barley	ton/acre	2.30	1.13	0.76	1.30	0.35	1.17
3.	Continuous Wheat	bu/acre	64.0	41.0	27.0	43.0	14.0	37.8

[a] 2001 Safflower yield is estimated for 2001.

Table 2. Revenues and Costs by Year, Continuous No-till Spring Cropping Systems Project, Adams County, WA, 1997 - 2001

Rotation	Year	Revenue	Var. Cost	Total Cost
		--- $ per rotational acre ---		
Saff/Y.M./SWSW/SWSW	1997	187.73	55.78	135.09
	1998	97.40	56.06	110.64
	1999	78.18	62.20	109.30
	2000	98.22	69.57	116.13
	2001[a]	43.33[a]	51.58[a]	80.88[a]
SWSW/Spring Barley	1997	205.51	60.22	144.88
	1998	114.72	53.98	110.32
	1999	79.00	55.38	99.45
	2000	128.59	71.09	127.62
	2001	34.88	55.67	86.83
Continuous SWSW	1997	215.04	60.22	148.40
	1998	137.76	54.00	118.36
	1999	90.72	55.16	103.48
	2000	144.48	70.86	133.03
	2001	47.04	55.28	89.19

[a] 2001 Safflower yield is estimated.

Table 3. Comparison of Net Returns by Rotation and Year Between for Three No-Till Spring Crop Rotations, Adams County, WA.

	Net Returns Over Total Costs					1997 - 2000		1997 - 2001	
Rotation	1997	1998	1999	2000	2001	Avg.	S.D.	Avg.	S.D.
	------ $ per rotational acre ------								
Saff/YM/SWSW/ SWSW	52.64	-13.23	-31.12	-17.91	-37.55[a]	-2.41	37.47	-9.43[a]	36.06[a]
SWSW/Spring Barley	60.63	4.40	-20.45	0.97	-51.96	11.39	34.62	-1.28	41.25
Continuous SWSW	66.64	19.40	-12.76	11.45	-42.15	21.18	33.25	8.52	40.39

[a] 2001 Safflower yield is estimated.

HOW THE 2001 DROUGHT AFFECTED THE ECONOMIC RISK OF CONTINUOUS NO-TILL HARD RED SPRING WHEAT IN ADAMS AND BENTON COUNTIES EXPERIMENTS

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This report provides results updated through 2001 on the experiments at Ralston in Adams County and the Horse Heaven Hills in Benton County. This report will focus on the economic effects of the 2001 drought at these sites.

Ralston. These experimental trials were initiated in August 1995 on a farm near Ralston in an 11.5 inch annual rainfall zone. The main trials at the site evaluated four tillage/crop rotation systems: a) conventional/minimum tillage SWWW/fallow; b) no-till soft white spring wheat (SWSW)/chemical fallow; c) continuous no-till HRSW; and d) no-till HRSW/no-till spring barley (SB). Above average precipitation in 1996-98 favored both spring and winter grain yields, but yields for both spring and winter grains were reduced by dry conditions in 1999-2001 (Table 1). The 2001 drought, with October-September precipitation of only 7.22 inches, reduced all yields, but continuous no-till spring grains were especially hard hit. In 2001 continuous HRSW, HRSW after SB, and SB after HRSW suffered yield losses 67, 79, and 84 percent, respectively, compared to their 1996-2000 averages. In contrast, the comparable 2001 yield reductions for SWWW after fallow and SWSW after fallow were "only" 46 and 56 percent.

Table 2 shows that the 2001 drought decreased average yields for all Ralston crops, but that yield risk as measured by the statistical coefficient of variation (C.V.) for the experiment duration was nearly doubled, or was doubled, for several crops. For example, the drought year increased the C.V. for continuous HRSW from 23 to 38 percent, and for HRSW after SB from 17 to 41 percent.

Because the higher production costs for spring cropping systems are still incurred in a drought year while yields and revenue are drastically reduced, it is not surprising that net returns plummet. Table 3 shows that losses for continuous HRSW more than quintupled in 2001 to -$145.03/acre. Losses with HRSW/SB were equally low in 2001. While SWWW/fallow averaged $16.29 over total costs during 1996-2000 at Ralston, it lost $39.76 per rotational acre in 2001. These results show that spring cropping was more vulnerable to downside risk in a drought year. The average $38/acre disadvantage of continuous HRSW versus SWWW/fallow during 1996-2000 ballooned to a $99/acre disadvantage in 2001. Furthermore, the net returns in Table 3 include decoupled AMTA and supplemental government payments estimated at $29/acre. The results do not include crop insurance claims which would have assisted growers who purchased coverage for 2001 (but would have added to production costs without payoff in higher yielding years).

Table 1. Annual Crop Yields by Rotation, Ralston.

Crop/Rotation	1996	1997	1998	1999	2000	2001
SWWW (bu/ac) swww/fallow	78	64	73	58	73	37
SWSW (bu/ac) swsw/chem fallow	51	61	62	38	50	23
HRSW (bu/ac) cont. hrsw	40	55	39	32	34	13
HRSW (bu/ac) hrsw/sb	43	56	42	37	39	9
SB (met. tons/ac) hrsw/sb	0.89	1.52	1.49	0.90	1.02	0.19

NOTE: Yields reflect typical moisture and chaff levels.

Table 2. Average and Coefficient of Variation (Percent) of Crop Yields by Rotation and Period, Ralston.

Crop/Rotation	Avg. 96-00	Avg. 96-01	C.V. 96-00	C.V. 96-01
SWWW (bu/ac) swww/fallow	69	64	12	23
SWSW (bu/ac) swsw/chem fallow	52	48	19	31
HRSW (bu/ac) cont. hrsw	40	35	23	38
HRSW (bu/ac) hrsw/sb	43	38	17	41
SB(metric tons/ac) hrsw/sb	1.16	1.00	27	49

NOTES: Yields reflect typical moisture and chaff levels.
Coefficient of Variation (CV) = (Standard Deviation/Average)100

Table 3. Net returns over total costs ($/rot. ac) for Phase I Ralston rotations for 1996-2000 average yields and for 2001 drought year yields.

Rotation	1996-2000	2001
SWWW/ fallow	16.29	-39.76
SWSW/ chem fallow	-11.99	-62.16
Cont. HRSW		
actual protein	-25.55	-145.03
HRSW/SB		
actual protein	-13.73	-139.14

NOTE: Net returns include estimated AMTA and supplemental government payments for 2001.

Horse Heaven Hills. This experiment was initiated in 1997 on a farm in the Horse Heaven Hills of Benton County, a 6.5-inch annual rainfall region. The experiment compares conventional tillage winter wheat-fallow (WW-fallow), the historically dominant rotation in this arid region, to continuous no-till hard red spring wheat (HRSW). Table 4 shows that continuous no-till HRSW averaged only 10 bu/ac over 1997-2000. Protein was well below 14% in the first two years and just above 14% in last two drier years. WW after fallow, on the other hand, averaged 24 bu/ac in 1997-2000 including an area record 41 bu/ac in1998. In contrast, only 2.4 bu/acre WW after fallow and 0.6 bu/acre continuous HRSW were harvested in the 2001 drought year. The year 2001 was actually the third year of drought at the site with annual precipitation between four and five inches (Table 4). Seasonal distribution of rainfall was also poor for spring crops in 2001.

The exceptionally low yields in 2001 reduced experiment average yields marginally and markedly increased the measure of yield risk. The C.V. for 1997-2001 versus 1997-2000 grew from 57 to 78 percent for SWWW and from 63 to 85 percent for HRSW. These results show the drier Horse Heaven Hills site (av 6.5 inches/yr/ppt) had higher yield risk than the Ralston site (av 11.5 inches/yr/ppt). The Horse Heaven site had a HRSW yield C.V. through 2001 of 85 percent compared to only 38 percent at Ralston. For winter wheat after fallow the comparison is 78 percent versus only 23 percent. Interestingly the yield risk for winter wheat after fallow and continuous HRSW at the Horse Heaven Hills experiment is about the same, 78 versus 85 percent (Table 4). At Ralston, on the other hand, winter wheat after fallow has only three fifths the yield risk of HRSW, 23 versus 38 percent.

The coefficient of variation, or standard deviation, provides only one measure of risk, one based on variability around the average. Many farmers and business people define risk alternatively as "probability of loss" or probability of income below zero. The standard deviation of net returns over 1997-2001 at the Horse Heaven Hills experiment is \$13.72/acre and \$15.74/acre for continuous HRSW and conventional winter wheat/fallow, respectively. This would suggest that the economic risk is slightly higher for wheat-fallow. However, the "probability of loss" (considering government payments of about \$10/acre) is 100% (five years out of five) with continuous HRSW and only 40% or two years out of five with wheat-fallow. Even this understates the advantage for wheat-fallow since the magnitude of the losses are much higher with continuous HRSW (Table 5).

Table 5 compares gross returns, total costs, and net returns over total costs for the WW-fallow and HRSW systems in the Horse Heaven Hills Experiment for 1997-2001. Gross returns on an annual per acre basis averaged slightly less for HRSW, but production costs for HRSW were double those for WW-fallow. Costs for the WW-fallow system, which were modeled after the host farmer's practices, are the lowest we have observed anywhere in the U.S. Fallow tillage costs on this farm are reduced to the minimum using efficient machinery acquired and maintained at minimal cost. During dry years, no fertilizer is applied. Chemical weed control is limited to inexpensive herbicides like 2,4-D. Farm-grown grain is kept and treated for seed. While the HRSW production costs are low compared to higher rainfall regions, the more regular use of fertilizer and herbicides, plus every year no-till seeding and harvesting drives the HRSW total cost to nearly double that of WW-fallow. In summary, HRSW averaged a loss of \$44/ac/yr while the WW-fallow lost only \$3 over 1997-2001. Decoupled government payments might add another \$10/acre returns per year for both cropping systems. Total costs in Table 5 include an allowance for the farmer's labor, land, and machinery investment. Interestingly, winter wheat-fallow budgets for some higher moisture regions have showed negative net returns during recent years.

The pattern of economic returns over the three-year (1999-2001) drought at the Horse Heaven Hills site is illuminating. The drought conditions reduced yields and net returns of continuous HRSW hard from 1999 onward (Tables 4 and 5). However, the resilient winter wheat-fallow system held its own somewhat in 1999 and 2000 by cutting costs and possibly relying on moisture reserves. But, by 2001, the persisting drought finally "caught up" with the wheat-fallow system and yields and profit plummeted.. It also seems clear that seasonal distribution of precipitation as well as annual total is important.

Table 4. Crop Yields and Precipitation, Horse Heaven Hills Experiment, 1997-2001.

Year	Ppt. (In.) (Aug. - July)	Wheat Yield (Bu/Ac) WW ff. Fallow	Cont. HRSW
1997	9.4	27	14
1998	7.9	41	18
1999	4.3	8	4
2000	4.8	20	6
2001	4.4	2.4	0.6
Av. 97-00	6.6	24	10
Av. 97-01	6.2	20	9
CV 97-00	37%	57%	63%
CV 97-01	38%	78%	85%

Note: Coefficient of Variation (CV) = (Standard Deviation/Average)100

Table 5. Annual Costs and Market Returns, Horse Heaven Hills Experiment.

Year	Rotation	Gross Returns ($/Ac)	Total Costs ($/Ac)	Net Returns ($/Ac)
1997				
	WW-Fal	45.58	39.51	6.07
	HRSW	40.00	83.61	-43.61
1998				
	WW-Fal	70.86	54.82	16.04
	HRSW	63.90	88.53	-24.63
1999				
	WW-Fal	14.62	29.81	-15.19
	HRSW	16.18	69.94	-53.76
2000				
	WW-Fal	34.06	33.90	0.16
	HRSW	24.66	62.88	-38.22
2001				
	WW-Fal	4.09	26.79	-22.70
	HRSW	2.80	62.59	-59.79
Averages				
	WW-Fal	33.84	36.97	-3.12
	HRSW	29.51	73.51	-44.00

Notes: Returns exclude government payments and crop insurance claims. To convert to comparable per acre basis, costs and returns for winter wheat-fallow include one-half acre of wheat and one-half acre of fallow.

Summary Continuous Spring Cropping. Six- and five-year experimental results at Ralston and the Horse Heaven Hills have clearly shown that the continuous no-till spring grain systems tested are not economically competitive with the conventional/minimum tillage winter wheat fallow systems. Furthermore, the spring cropping systems expose the grower to significantly more economic risk in dry years. Of course, more yield enhancing research and public support for these soil and air quality conserving spring cropping systems, possibly using different wheat classes like soft white spring wheat, might make them more competitive with the relatively profitable, but erosive, winter wheat-fallow system. Researchers should also investigate other soil conserving systems, such as reduced tillage fallow-soft white winter wheat. Minimum tillage SWWW-fallow systems tested at Lind and at Ralston employed substantially less tillage during the fallow operation than was typical on most area farms. These "minimum tillage" SWWW-fallow systems, which are expected to cut dust emissions by 54 percent relative to conventional systems, might provide a cost effective intermediate cropping system for the region.

Results from farmer surveys and Cooperative Extension farmer panels have indicated that farmers may be able to trim the cost of production for HRSW below the estimates presented here. If possible, this would improve their competitiveness with winter wheat-fallow.

Other research has shown significant public valuation for higher levels of air quality which are provided by soil conserving cropping systems. Public cost sharing for soil conserving annual spring cropping would assist innovative growers adopt these systems profitably. However, Congress has not been inclined recently to substitute "green payments" in a major way for decoupled subsidies.

WINTER WHEAT AFTER FALLOW YIELD SURVEY RESULTS FOR RITZVILLE GROWERS, ADAMS COUNTY, WA

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Since 1997, Washington State University has been conducting a continuous no-till spring cropping systems project near Ritzville, WA, on the Jirava Farm. One purpose is to compare the profitability of several no-till spring cropping rotations with that of the conventional winter wheat/summer fallow system. To facilitate this comparison, yields of soft white winter wheat (SWWW) after fallow were surveyed on fields that were within six miles of the Jirava Farm. The yield survey results are reported here. The complete comparison will be reported later.

Table 1 summarizes surveyed winter wheat yields by farmer and by year. A number identifies each of the 10 participating farmers. Farmer 3 reported yields for three different fields. The table shows the range, standard deviation (S.D.) and average yield for each year over farmers, for each farmer over years, and for the entire data set.

The yields for each year were also divided into the top, middle and lower one-thirds of the sample and the averages reported for each group. For every year there are twelve reported yields, allowing four yields in each group. Individual farmers can potentially move from one group to another in different years based on their performance.

Not surprisingly, average yields varied considerably over 1997 to 2001 with a high annual average of 72.3 bu/ac in 1997 and a low of 35.5 bu/ac in 2001. Every surveyed farmer experienced his/her lowest yield in 200l, a drought year. For some individuals, the contrast over years was extremely large. Farmer 10, for example, harvested 70 bu/ac in 1997 and always remained above 50 bu/ac through 2000, but harvested only 17 bu/ac in the 2001 drought year. In contrast, field 3c ranged only from 62 to 39 bu/ac from 1997 to 2001. As expected, S.D.'s over years for individual farmers were higher—ranging from 8.4 to 20.6 bu/ac—than S.D.'s over farmers for single years, which ranged from only 7.4 to 12.3 bu/ac.

As expected, yield patterns over time for the upper, middle, and lower one third groups tend to follow the same pattern as the overall average; however, there is a 13 to 23 bu/ac "spread" between the upper and lower groups, depending on the year. For this sample, this yield spread was highest in 1997, the highest yielding year. In high yielding years, there is a greater yield potential to be foregone by poor microenvironments or by management problems. For example, yields range from 50 to 92 bushels over the 12 samples in 1997, a year with favorable rainfall. Of course, some yield variation across farms within a year is expected due to differences in land quality, pest incidence, and site-specific weather. Also, yields alone will not determine profits; production costs, which were not surveyed, will also play a role.

Table 1. SWWW after fallow yield results (bu/ac) for growers within six miles of Jirava Farm, Adams Co., WA, 1997–2001.

Farmer I.D.	1997	1998	1999	2000	2001	Range	Average	S.D.
1	75	69	66	61	38	38 – 75	61.8	14.2
2	73	69	52	69	46	46 – 73	61.8	12.0
3a[a]	91	47	66	57	42	42 – 91	60.6	19.3
3b[a]	72	59	55	56	33	33 – 72	55.0	14.1
3c[a]	62	54	53	55	39	39 – 62	52.6	8.4
4	92	63	61	76	46	46 – 92	67.6	14.3
5	50	50	65	55	30	30 – 65	50.0	12.7
6	60	59	48	58	28	28 – 60	50.6	13.5
7	76	52	60	69	37	37 – 76	58.8	15.2
8	70	56	58	54	34	34 – 70	54.4	13.0
9	77	50	53	66	36	36 – 77	56.4	15.7
10	70	63	57	53	17	17 – 70	52.0	20.6
Upper 1/3[b]	84	66	65	70	43	43 – 84	65.6	14.7
Middle 1/3[b]	73	57	58	58	36	36 – 73	56.3	13.2
Lower 1/3[b]	61	50	52	54	27	27 – 61	48.6	12.9
Range	50 – 92	47 – 69	48 – 66	53 – 76	17 – 46	17 – 92[c]		
Average	72.3	57.6	57.8	60.8	35.5		56.8[c]	
S.D.	11.9	7.4	10.2	12.3	8.1			14.5[c]

[a] Farmer #3 reported yields on three different fields.
[b] Group yield averages are reported for 1997 through 2001.
[c] These three statistics apply to the entire data set.