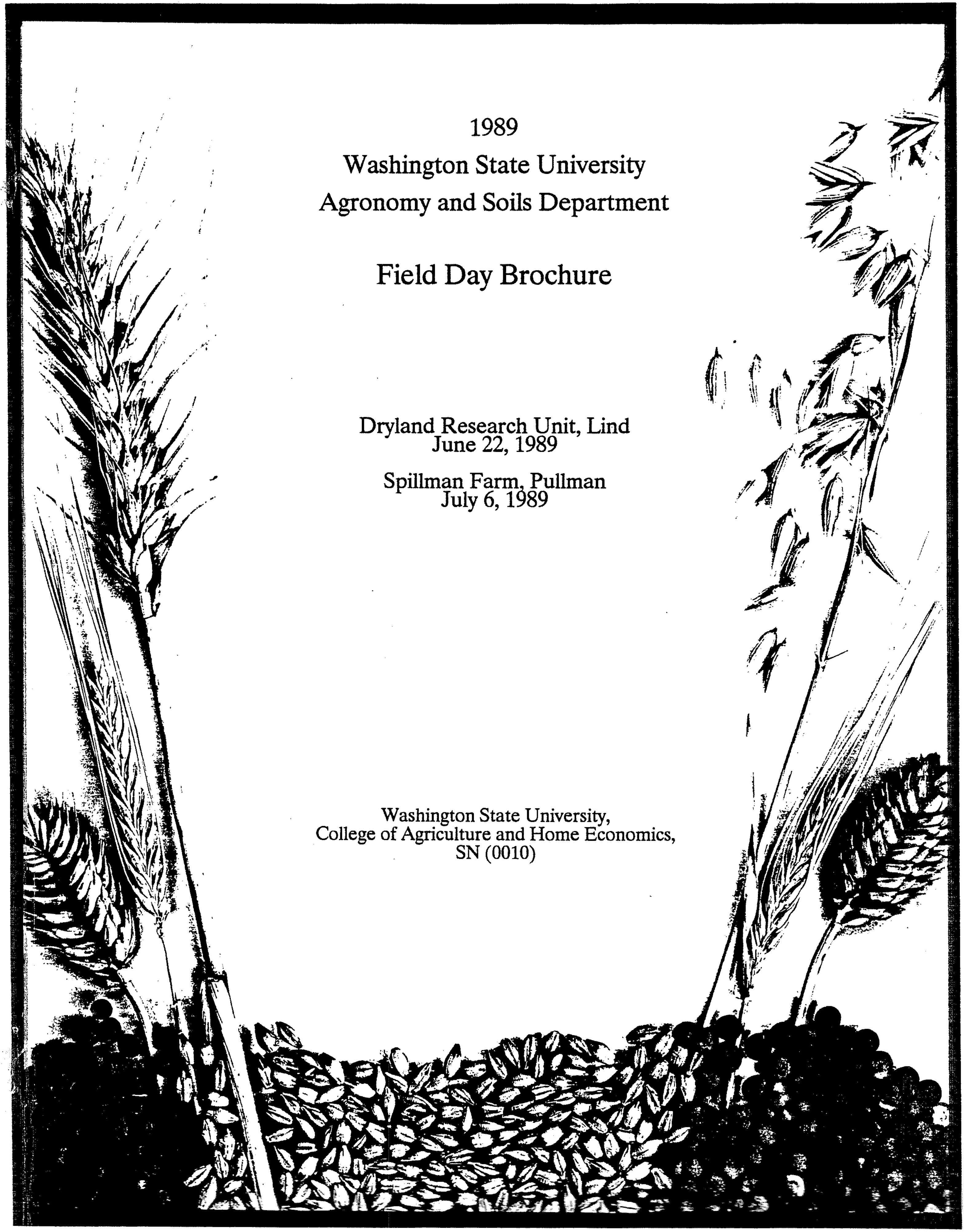

1989

Washington State University
Agronomy and Soils Department

Field Day Brochure

Dryland Research Unit, Lind
June 22, 1989

Spillman Farm, Pullman
July 6, 1989

Washington State University,
College of Agriculture and Home Economics,
SN (0010)

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COOPERATIVE PERSONNEL AND AREA OF ACTIVITY

Samuel Smith.........................President, Washington State University
L. E. Schrader................Dean, College of Agriculture & Home Economics
Bonnie Johnson....................Interim Director of Resident Instruction
J. J. Zuiches.........Director of Research, College of Ag. & Home Economics
F. L. Poston.............................Director of Cooperative Extension
D. G. Miller...............................Chairman of Agronomy and Soils

Cereal Breeding, Genetics and Physiology

R.E. Allen, J.A. Pritchett, L.M. Little, USDA................Wheat Genetics
E. Donaldson, M. Nagamitsu, B. Sauer, Dry Land Res. Unit, Lind ....Wheat
C.F. Konzak, M.A. Davis..........................Wheat Breeding & Genetics
S.E. Ullrich, C.E. Muir, D.A. Deerkop............Barley Breeding & Genetics
C.J. Peterson, D.F. Moser, K. Hinnekamp,
V.L. DeMacon..Wheat Breeding
R.L. Warner, A. Kleinhofs......................Cereal Evaluation Laboratory
S.E. Brauen, Puyallup...................................Varietal Testing
B.C. Miller, P.E. Reisenauer, Pullman...............Cereal Cropping Systems
M.K. Walker-Simmons, J. Sesing-Lenz.......................Cereal Physiology

U.S.D.A. Western Wheat Quality Laboratory

G.L. Rubenthaler.........................Research Cereal Chemist in Charge
H.C. Jeffers...Research Technologist
P.D. Anderson, A.D. Bettge, D. Engle...........Physical Science Technicians
G.E. King..Early Generation Testing

Cereal Diseases

S.D. Wyatt, T. Murray............Cereal Viruses, Foot Rots & Other Diseases
R.J. Cook, D. Weller, Cooperative USDA...................Root Rot Diseases
R.F. Line, Cooperative USDA..............................Flag Smut Control

Breeding and Culture of Dry Peas and Lentils
F.J. Muehlbauer, J.L. Coker, R. Short, and S. Spaeth, USDA

Weed Control
A.G. Ogg, F.L. Young, and D.R. Gealy, USDA
E.P. Fuerst

Fertility and Management
W.L. Pan, E.T. Field, C.F. Engle
R.I. Papendick, D. McCool, K. Saxton, and J. Smith, USDA

Cereal Crop Seed Increase
T.D. Wagner

USDA Plant Material Center
Clarence Kelly, Manager

Spillman Farm Manager
Ray Nelson

Dry Land Research Unit Farm Manager
Dick Hoffman

ACKNOWLEDGEMENT OF CONTRIBUTORS IN SUPPORT OF 1988-1989 RESEARCH

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 wheat, barley, pea and lentil growers, through the commodity assessment programs, as well as contibutions from the agricultural industry, which facilitates our overall agricultural research progress. In addition, a special acknowledgement goes to the numerous individual farmer cooperators who generously contribute their land, labor, equipment, and time. These contributors and cooperators include:

Fertilizer, Seed and Amendments

Agr. Alternatives
W. Brotherton Seed Co
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WA Wheat Commission
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E.I. DuPont De Nemours & Co.
Gilmore, Inc.
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Rhone-Poulenc, Inc.
Dick Stueckle
WA Barley Commission

Dry Land Unit, Palouse Conservation Station and Spillman Farm Field Days Contributors

Adams County Wheat Growers
American Malting Barley
Lind Grange
McGregor Co.
Puregro Co. (Ritzville, Harrington & Wilbur)
Wilfac
Whitman County Wheat Growers

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Gene Aune	Lacrosse
Lynn Ausman	Asotin
Jim Babb	Rosalia
Dale Bauermeister	Connell
Bud Benedict	Asotin
Jean Bippes	Farmington
Albert/Doug/Dan Bruce	Farmington
Ralph Camp, Jr.	Lacrosse
Marvin Carstens & Sons	Reardan
Earl Crowe	Farmington
Van Deffenbaugh	Kennewick
Dal Dietrich/Wilke Farm	Davenport
Tim Doneen	Farmington
Roger Dye	Pomeroy
Jim Evans	Genesee
James Ferrel	Walla Walla
Bob Frazier	Walla Walla
Dave/Merle Harlow	Pullman
Norman Heitstuman	Uniontown
Curt Hennings	Endicott
Vince Hensel	Palouse
Gordon Hill	Colfax
Ed/Henry Hiller	Pomeroy
Hoffman Farms	Clyde
Lowell Huffman	Lenore
Tom Hyslop	Espanola
Albert Jacobson	Waterville
Hollis Jamison	Garfield
Dave Jones	Walla Walla
Laurence Juchmes	Waterville
Ron Juris	Bickleton
Keith Kaiser	Goldendale
John Kenny	Dayton
Charles Keno	Fairfield
Larry Kimbel	Pomeroy
Koller Farms	Mayview
Robert Kramer	Harrington
Jerry Krause	Creston
Dick Kriebel	Garfield
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Quentin Landreth	Espanola
Paul Mader	Pullman
Keith Mader	Palouse
Fred Mader	Colfax
Steve Mader	Pullman
McGregor Farms	Hooper

Farmer Cooperators

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Gary Morris	Potlatch
Bruce Nelson	Farmington
Gary Osborn	Troy
Lynn Polson	Waterville
Don Quist	Palouse
Lowell Richter	Dayton
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Monty Schaffer	Horse Heaven
Mike Sodorff	Colton
John Schlomer	Winona
Harold Schultheis	Colton
Tom Schultz	Reardan
Mort Swanson	Palouse
Elmo, Larry, Jerry Tanneberg	Coulee City
Steve Taylor	Ralston
TIG Ranch	Lind
Tony Viebrock	Waterville
Marty Weber	Colton
Don/John Wellsandt	Ritzville
Lyle West	Palouse
Curt White & Sons	Lamont
Bob/Dick Whitman	Lapwai
Dick/Ron Wilbourn	Pullman
Paul Williams	Reardan
Glen Wolf	Deer Park

A Dedication to

DR. H. H. CHENG

It is a pleasure for the Agronomy and Soils Department of Washington State University to acknowledge the outstanding contributions of Dr. H. H. Cheng, who has accepted a position of Head of the Department of Soil Science at the University of Minnesota. Dr. Cheng is known to all of us as "HH" because most of us can't pronounce his real name. He worked at WSU for the past 24 years, not only in research and teaching, but also in administration. He and his wife "Jo" have two sons who are in college. HH and Jo are known for their dedication and service to church and community activities and to music and the arts.

The Chengs came to WSU in 1955 from Iowa State University where HH continued what was the start of a long and distinguished career in soil biochemistry. He is recognized for his research on nitrogen fractionation, transformations, and isotopes in soil and water. Some of the very first work on using nitrogen isotopes in potato fertilization was conducted by Dr. Cheng in the Columbia Basin. Dr. Cheng's research on the breakdown, movement, and adsorption of pesticides in soil is well known and provides basic information needed for predicting the fate of chemicals in the environment and especially groundwater. His contributions on methods for extracting and analyzing organics are known and appreciated by many scientists.

Administratovely, Dr. Cheng served as Chair of the Program in Environmental Science and Regional Planning from 1977 to 1979, and most recently as interim Chair. He has also served as Associate Dean of the Graduate School for four years and as Interim Chair in Agronomy and Soils after Dr. Engibous retired in 1986. We always relied on HH for his advice on matters relating to rules and procedures at WSU. We will miss him. We will also miss the HH Cheng "filing system" in his office which no other faculty member has been able to master.

The Department of Agronomy and Soils, WSU, and Pullman wish HH and Jo well in their new environment. We trust that HH has thoroughly read his book on "Minnesota Language Systems" and is able to speak Minnesotan by now.

A Dedication To

DR. JAMES A. KITTRICK

When Jim Kittrick first came to WSU the institution was called the State College of Washington and Stadium Way was a gravel road. He was appointed July 1, 1955. His lab was a small space in Wilson Hall, across from the CUB.

Jim grew up near Milwaukee, Wisconsin. He attended Wauwatosa High School, graduating in 1947, and then went on to do undergradiate and graduate work in soils at the University of Wisconsin. He obtained his Ph.D. degree in Soils (Mineralogy) from the University of Wisconsin in 1955, the year he came to WSU. He worked at various jobs during his undergraduate years, but one of the most exciting must have been the tending of 30 colonies of bees!

Jim's research has been on soil mineral weathering and methods for determining mineral stabilities or free energies of formation. This research is of fundamental importance to many of the environmental issues we face today, including proper control of plant nutrient concentrations in soil to minimize environmental hazards, and movement of toxic or hazardous materials in soils. Jim developed the application of the solubility method to the point that it could be used for the complex minerals found in soils. He pioneered the determination of the stability of complex aluminosilicates using solubility methods. His work has been used and recognized throughout the world, and has established WSU as a leading institution in application of thermodynamic principles to the science of mineral weathering.

Jim is remembered as one of the outstanding teachers by former students.

Jim's accomplishments in his profession were partially recognized through election to Fellow of the Soil Science Society of America and American Society of Agronomy.

Jim's contributions have not been totally in the areas of hard science. He is also active in conservation and environmental issues. He served as chairman of the program in Environmental Science at WSU, and led the effort to obtain wilderness classification for the Wenaha-Tucannon Wilderness. He also helped define some of the conservation legislation in the 1985 Farm Bill. Congratulations, Jim, on an outstanding and productive career!

Jim and his wife Lucy will be moving to the Olympic Peninsula to begin retirement later this summer.

A Dedication To

GLADYS V. KERNS (TORY)

In recognition of her almost 24 years of service to the Department of Agronomy and Soils, we are pleased to dedicate the 1989 Field Day Brochure to Mrs. Tory Kerns. Tory retired on June 30, 1988.

Tory was raised in High Prairie, Alberta, Canada. She attended Garbutt Business College in Lethbridge, Alberta, Canada, from November 1943 to October 1944. On March 31, 1945, she married James C. Kerns. They immigrated to the United States in 1950, first to Garfield, Washington; a year later to Pullman, Washington; six months later to Spokane, Washington; and in 1952 back to Jim's birthplace near Potlatch, Idaho, where they are presently residing. Tory and Jim are the proud parents of six children, Ralph, Robert, James, Glady, David, and Richard.

Before joining Agronomy and Soils she was employed for approximately one year by the Physical Sciences Department and Associate Dean offices in the College of Agriculture at the University of Idaho. In March 1964 she was hired as Clerk/Stenographer working for Warren Starr, Ray Gilkeson and Merle Switzer in the Department of Agronomy, WSU. She then was promoted to Secretarial/Stenographer in June 1964 working for the Chairman, Dr. B. R. Bertramson. In April 1969 she was promoted to Senior Secretary by Dr. C. D. Moodie, Chair of the department. In March 1981 she was promoted to Administrative Services Manager by Dr. J. C. Engibous, Department Chair, and continued in that capacity until her retirement in June 1988. During her term as Administrative Services Manager she effectively managed the large fiscal and inventory activities of Agronomy and Soils. During her time in the department she commuted 23 miles (one way) daily. Dr. Dwane Miller, current Department Chair, commented, "She was a very dedicated and efficient member of the department. She always got the job done no matter how monumental the task."

A Dedication To

DR. FRED KOEHLER

Dr. Fred Koehler will fully retire this summer after serving the past year on a 40% appointment. His 31 years of service to WSU and to agriculture of eastern Washington has left a record of achievement which has benefited eastern Washington agriculture. His broad experience and research insights have also been passed on to many students who have taken his soils classes. Some of his contributions to soil fertility management for cereal production include his "hilltop" phosphorus fertilizer trials, his work in determining the areas and conditions under which sulfur fertilizer is needed and, of course, a great deal of information on nitrogen fertilizer management. He also carried out a moderately extensive survey of micronutrient needs. For all of these nutrients his research provided information relative to: (1) where each nutrient is generally needed; (2) rates needed; (3) proper time of application; (4) proper placement of fertilizer; (5) the best form and management practices for each of the different forms, and; (6) field plot and soil test data to calibrate soil tests for these nutrients for the various soil conditions of eastern Washington.

Of special significance was his research on soil fertility management for the new semidwarf wheats that Dr. Vogel was developing. These new varieties had an obviously higher yield potential than existing varieties. However, for more accurate and reliable fertilizer recommendations it would be necessary to know how much more efficient they were in utilizing two of the major inputs into wheat production, available soil moisture and nitrogen. After extensive and well-managed field and laboratory research, he discovered that they were over 15% more efficient in utilizing available soil moisture, and over 10% more efficient in nitrogen utilization. This information was compiled and incorporated into fertilizer recommendations when these new varieties were available for commercial production. Coordinated research such as this maximizes the output from research dollars, helps growers reduce production costs, and increases agriculture's contribution to the state's economy.

Thanks, Fred! We are happy that you and Helen will continue to live in Pullman. We wish you many happy years in retirement!

A Dedication To

GORDON L. RUBENTHALER

Gordon L. Rubenthaler retired on June 2, 1989 after 33 years of service with USDA-ARS. Gordon directed research of the Western Wheat Quality Laboratory (WWQL) from 1968 until he retired. Raised on a livestock-grain farm in Nebraska, Gordon began working at the USDA-ARS Manhattan, KS Quality Lab in 1958, while he was studying for a BS degree in Cereal Technology. He later obtained his MS degree from Kansas State University. After graduation he worked in the Manhattan Lab as an Aide and then as a Cereal Technologist until 1966, when he transferred to the Pullman Lab. Gordon has had a distinguished career. He and his co-workers have made national and international impact on wheat technology. Through his ingenuity the lab developed improved ways to evaluate lysine content via the NIR, rapidly measure gas production of wheat doughs, improve the accuracy of experimental mills, measure kernel hardness, and developed tests for evaluating western wheats for sponge cake, steam bread, oriental noodles, flat breads, and dual purpose flour quality. Gordon established the Collaborative Test Program, which has become the cornerstone of the lab's wheat evaluation effort. This program now involves pilot testing of proposed wheat varieties by 19 milling and baking organizations in the USA, Japan, Korea, Philippines, Morocco, and Egypt. Although Gordon has authored or co-authored over 150 publications, he insisted that evaluation of breeding material remain the main priority of the WWQL. Under his direction the WWQL has tested annually about 3,000 advanced lines and 5,000 early generation lines. These samples were submitted by all of the major breeding programs of the western USA. The WWQL has been directly involved in the development of over 40 wheat varieties including club, soft white, hard white, hard red, and dual purpose types. Under Gordon's leadership the WWQL became the chief technology transfer center for western wheat quality. Dozens of domestic and foreign wheat industry groups visit the lab each year. At the request of the USA wheat industry and the US Government, Gordon traveled to Japan, China, Morocco, and Egypt to learn how these countries use our wheat and to advise them on the unique quality properties of our wheats.

Gordon also served as adjunct professor in the Food Science Department of WSU. He advised several graduate students and assisted in teaching courses and gave seminars. Gordon worked tirelessly to obtain modern and expanded facilities for the WWQL. He had a lead role in development of the plans for phase II of the Food Science Building, which will house the lab by 1991.

After his retirement Gordon plans to continue important research on wheat quality by working on a part-time WSU appointment. His plans call for winding up some unfinished research and adopting NIR methods to predict wheat flour quality.

A Dedication To

DR. DEAN SWAN

Dr. Dean Swan came to Washington State University in 1966 as State Weed Specialist following 1 year in a similar position for Arizona and 7 years of weed research for Oregon State University on their Pendleton Branch Station.

Dean grew up on a diversified farm near Wheatland, Wyoming. He served during World War II with the Army Airforce in Panama, and following the war entered the University of Wyoming. He earned a Bachelor's degree in Agricultural Education, taught one year at the high school level in Shadron, Nebraska, and returned to the University of Wyoming for a Master's degree. It was in 1954 that, with the M.S., he joined the OSU faculty at Pendleton. As noted, some seven years later he entered graduate school at the University of Illinois, from which he earned the Ph.D. degree in Agronomy and Weed Control.

Dean particularly enjoys working with people, and some of his favorite people are farmers and farm agents. However, his likes also include the more meticulous aspects of applied research, and particularly the recording of results on film. His research experiences included two one-year sabbaticals at Oxford, England as a research fellow. It was there that he developed the photographic abilities for which he is likely to be remembered.

Dean is a member of the Weed Science Society of America, Western Society of Weed Science, Washington State Weed Association, and Sigma Xi. Dean was awarded an Honorary Membership in the Washington State Weed Association in 1986 "for many significant contributions", and has won several awards in WSSA photo contests.

His book <u>Weeds of Eastern Washington and Adjacent Areas</u>, written with Mrs. Xerpha Gaines and Clint Keller, is a first reference by many of the region's farmers. And, although Dean's retirement was official April 30, 1989, his efforts continue. His next book, one that features pictures of weed seeds and seedlings, should add significantly to his remembrance.

HISTORY OF THE DRY LAND RESEARCH UNIT

On April 1, 1915, Experiment Station Director I. D. Cardiff announced the establishment of the Adams Branch Experiment Station. It was "created for dissemination and conduction of demonstrations and experiments in the semi-arid portion of the state".

Adams County has played an important part in the history of the station. The county donated $6,000 to start the station and the land has been donated by the county. In the early '30s, during the depression, Adams County kept the station alive with a small appropriation until the College could fund the operation again. In 1965 Adams County deeded 318 acres to Washington State University; two acres were previously deeded, to make a total of 320 acres in the Dry Land Research Unit.

The first superintendent was the late Dr. M. A. McCall. 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." For 70 years this station has followed this policy of studying the problems associated with the 8 to 12 inch rainfall area.

In 1947 the station was named the Dry Land Experiment Station. This name was changed again in 1965 to the Dry Land Research Unit. In 1972 the administration of the station was moved into the Department of Agronomy and Soils. Although the administration was changed, the station is still devoted to dry land research. This experiment station has the lowest rainfall of any research station devoted to dry land research in the United States.

The present facilities include a small elevator which was constructed in 1937 for grain storage. A modern office and attached greenhouse were built in 1949 after the old office quarters were burned. In 1960, a 40' x 80' metal shop was constructed with WSU general building funds. In 1964, an addition to the greenhouse was built with a Washington Wheat Commission grant of $12,000 to facilitate breeding for stripe rust resistance. In 1966, a new deep well was drilled, testing over 430 gallons per minute. A pump and irrigation system were installed in 1967. The addition of a 12' by 60' trailer house, and improvements in 1966 and 1967 amounted to over $35,000, with more than $11,000 of this from Wheat Commission funds and the remainder from state funds. In 1983 a new seed processing and storage building was completed 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. The old machine storage, built shortly after the station was established, was removed in 1985. The major portion of the research has centered on wheat. Variety adaptation, wheat production management including weed and disease control, and wheat breeding are the major programs of research in recent years. Twenty acres of land can be irrigated for research trials. The primary purpose of irrigation on the Dry Land Research Unit is not to aid in the development of hard red winter wheats for higher rainfall and irrigated agriculture, but to speed up and aid in the development of better varieties for the dry land wheat summer fallow region. Although many varieties of wheat have been recommended from variety trials by the station, Wanser and McCall were the first varieties developed on the station by plant breeding.

Since 1916 an annual field day has been held to show farmers and interested businessmen the research on the station. This year marks the seventy-third field day. Visitors are welcome at any time and their suggestions are appreciated.

HISTORY OF SPILLMAN 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.

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 feet addition was added in 1981. In 1957 a well that produced 340 gallons per minute was developed. In 1968 the Washington Wheat Commission provided funds for a sheath 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, roadside seedings, and a conservation crop rotation including alfalfa and grass has been in use since the farm was purchased.

Ray Nelson was appointed farm manager in July 1981.

CLIMATIC DATA

The climatic conditions in the low rainfall area of eastern Washington, commonly called the Big Bend Area, are unique when compared to Great Plains wheat producing areas. As shown in Table 1, about 90% of the rainfall occurs from September 15 to June 30. This rainfall pattern coincides with the normal winter wheat growing season. In most wheat production areas outside the Pacific Northwest, a spring-summer rainfall pattern occurs. The efficiency of the moisture utilization is greater under our rainfall pattern with evaporation-transpiration rates during the months of maximum precipitation.

Table 1. Average temperature and precipitation at Dry Land Research Unit, Lind

Month	Temperature °F. Max.	Temperature °F. Min.	Precipitation 1988	Precipitation 1989	Precipitation 68 yrs. Av (in)
January	34	22	.43	.38	1.01
February	42	24	.01	.87	.87
March	53	32	1.09	2.15	.79
April	63	35	1.57	.90	.68
May	72	42	1.25		.78
June	83	45	.56		.83
July	90	52	.21		.25
August	90	50	T		.33
September	79	45	.94		.57
October	65	38	.14		.84
November	47	29	2.13		1.24
December	37	26	.41		1.27
			8.74		9.46

Climatic measurements are made daily with standard U.S. Weather Bureau instruments. Data recorded are maximum and minimum temperature, daily precipitation, relative humidity, daily wind movement, and daily evaporation. In addition, automatic instruments make a continuous record of soil and air temperatures and precipitation.

Table 2. Temperature and precipitation at Palouse Conservation Field Station, Pullman, 1988-89

	Monthly Avg. Temperature(F)		Precipitation (in)				
						Deviation from Avg.	
Month	Max.	Min.	30-Yr Avg.*	Monthly	Total Accum.	Monthly	Accum.
1988							
January	34.6	22.9	2.87	2.15	2.45	- .72	- .72
February	47.4	26.0	2.31	.89	3.04	-1.42	-2.14
March	48.3	30.8	2.09	2.56	5.60	+ .47	-1.67
April	59.5	38.2	1.56	2.00	7.60	+ .44	-1.23
May	65.5	41.0	1.58	1.76	9.36	+ .18	-1.05
June	72.6	46.8	1.56	1.43	10.79	- .13	-1.18
July	82.5	48.9	.64	.99	11.78	+ .35	- .83
August	84.4	48.0	.92	.04	11.82	- .88	-1.71
September	75.3	43.4	1.03	.91	12.73	- .12	-1.83
October	70.8	41.7	1.71	.75	13.48	- .96	-2.79
November	43.5	32.6	2.79	4.30	17.78	+1.51	-1.28
December	35.9	23.7	3.13	1.42	19.20	-1.71	-2.99
TOTAL	60.0	37.0	22.19		19.20		-2.99
1989							
January	36.1	25.0	2.87	3.27	3.27	+ .40	+ .40
February	30.9	17.1	2.31	1.37	4.64	- .94	- .54
March	46.3	31.3	2.09	3.45	8.09	+1.36	+ .82
April	61.0	38.0	1.56	.77	8.86	- .79	+ .03
TOTAL			8.83		8.86		+ .03
1988 CROP YEAR Sept. 1987 thru June 30, 1988			20.63		14.99		-5.64

* Thirty-eight year average for precipitation, 1948-1985

		Dirkwin	Cayuse	Steptoe	Kamiak
	·ephen Tres Hill 81 Lewjain Crew Dusty Hyak Madsen	Waverly Edwall Owens Penawawa	Appaloosa Monida	Advance-malting Belford-hay only Andre-malting Cougbar Morex-malting	Boyer Showin Hesk
EASTERN WASHINGTON					
Less Than 14 Inches Rainfall	Hatton Sprague Lewjain Batum Moro Tres Crew Hyak	Wampum Wavely Dirkwin Edwall Owens Penawawa McKay		Steptoe	Kamiak
CENTRAL WASHINGTON					
Under Irrigation	Daws Stephens Hill 81 Lewjain Dusty Madsen	Wampum Waverly Dirkwin Owens Penawawa McKay	Cayuse Appaloosa Monida	Andre Klage Steptoe Belford-hay only Cougbar	Boyer Hesk Showin
Snow Mold Areas	Sprague John Andrews				

WHEAT, BARLEY AND OAT CULTIVARS

WINTER WHEAT

Daws

Daws is a soft white common semidwarf wheat. The variety has about a 5 percent yield advantage over Nugaines. It is more winterhardy than Nugaines but is not as hardy as Wanser or McCall. Daws has good milling property and the flour quality is satisfactory. The variety emerges slower than Nugaines. Daws has good stripe rust resistance but is susceptible to Cercosporella foot rot, snow mold, dwarf smut, and Cephalosporium stripe (fungus stripe). It is moderately susceptible to leaf rust. Daws was developed by USDA-ARS and Washington State University.

Dusty

Dusty is a semidwarf soft white winter wheat developed for production in Washington, Idaho and Oregon. The variety has a common-type head with white chaff. It has a better yield record than Daws and Nugaines. The test weight is slightly less than Nugaines but higher than Daws. The straw strength of Dusty is weaker than that of Daws and Stephens, and it may lodge under high production. It is similar to Lewjain in winterhardiness, but is considerably less winterhardy than Daws. The variety does initiate growth earlier in the spring than Daws. Dusty is resistant to common bunt and has adult plant resistance to stripe rust. It is moderately susceptible to leaf rust, Cephalosporium stripe, and flag smut. It is susceptible to dwarf bunt, snow mold, stem rust, and Cercosporella foot rot. Dusty has satisfactory milling and baking quality. Dusty was developed by USDA-ARS and Washington State University.

Hill 81

Hill 81 is a soft white common semidwarf winter wheat. It is mid-tall with white stiff straw. The spike is awned with white. It is more winterhardy than Stephens but is not as winterhardy as Daws. Hill 81 has seedling resistance to local races of stripe rust and common bunt. It has good adult plant resistance to the current races of stripe rust and leaf rust. It is susceptible to Cercosporella foot rot and moderately resistant to Cephalosporium stripe. Hill 81 has maintained high yields, being comparable to Daws but with less yield than Stephens when winter injury is not a factor in yield. The variety has promising overall white wheat quality characteristics with quality similar to Nugaines. Hill 81 was developed by Oregon State University.

John

John is a soft white winter wheat with white chaff. The straw height is about the same as Sprague, but is weaker than most other varieties but superior to Sprague. Yields are slightly higher than Sprague. The emergence appears to be good. The snow mold resistance is comparable to Sprague. John has a slightly higher flour yield than Sprague; otherwise it is similar to Sprague in quality. It is similar to Sprague in stripe rust resistance but is slightly less leaf rust-resistant. John was developed by Washington State University and USDA-ARS.

Lewjain

Lewjain is a semidwarf white winter wheat with good dwarf bunt resistance. The variety has a common-type head with white chaff. The test weight of Lewjain is similar to Luke, being slightly lower than Nugaines and about the same as Daws. The straw of Lewjain is weaker than Daws and Nugaines. Lewjain is similar to Luke in winterhardiness, being slightly less winterhardy than Nugaines and considerably less than Daws. It has excellent resistance to stripe rust and is more tolerant to Cercosporella foot rot than Nugaines or Daws. The variety has excellent resistance to local races of common and dwarf bunt. Lewjain is more susceptible to flag smut than Nugaines. It is moderately resistant to Cephalosporium stripe. Lewjain shatters slightly more than Daws and Nugaines, but it is easy to combine and thresh. Reel speed should be held to a minimum to avoid excessive loss from head snapping. Lewjain has excellent milling quality but is not as good as most soft white club wheats. Baking tests have shown the flour has good quality for pastry, cookies, and soft white wheat products. Lewjain was developed by USDA-ARS and Washington State University.

Madsen

Madsen (WA007163) is a soft white winter wheat with resistance to strawbreaker and foot rot. It was released to the growers in the fall of 1988. Madsen is also resistant to the local races of stripe rust, leaf rust, and it has a good yield potential. It has a common-type head with white chaff. The milling and flour quality of Madsen is similar to that of Hill 81. Madsen was developed by USDA-ARS and WSU.

Sprague

Sprague is a soft white common wheat developed for the snow mold areas. The chaff varies white to gray-brown; the heads are small and awned. It has high tillering capacity from early seedlings but the straw is weak. The test weight of Sprague is below Nugaines but it has been above 60 pounds per bushel. Sprague has good resistance to snow mold and common bunt but is susceptible to dwarf bunt, stripe and leaf rusts, and Cercosporella foot rot. It has excellent emergence and good winterhardiness. Sprague was developed by USDA-ARS and Washington State University.

Stephens

Stephens is a soft white common wheat released at Oregon that is resistant to stripe rust and common smut. It is moderately resistant to Cercosporella foot rot. Stephens is susceptible to leaf rust, dwarf smut, flag smut, snow mold, and Cephalosporium stripe (fungus stripe). It is similar to Nugaines in emergence. The grain yields of Stephens are slightly higher than Nugaines, McDermid, and Hyslop. Stephens has the same winterhardiness as Hyslop. The milling and flour qualities of Stephens are similar to that of Nugaines. Stephens was developed by Oregon State University.

Crew

Crew was the first multiline wheat cultivar to be released in North America. Crew is a multiline developed to lessen the genetic vulnerability of the region's club wheat crop to stripe rust. Crew is made up of 10 separate lines. It appears to be more generally adapted to the club wheat region than other club wheats such as Paha and Faro. It is less damaged than current club wheat varieties by leaf rust and mildew. All of the 10 components possess seedling resistance and some have adult resistance to stripe rust. Crew is susceptible to strawbreaker foot rot. The variety is resistant to common bunt but it is susceptible to flag smut and Cephalosporium stripe. Crew yields more than Elgin, Moro and Paha and is comparable to Barbee, Faro, Tyee and Jacmar in yield. The yields of Crew are less than Daws. Crew was developed by ARS-USDA and WSU.

Hyak
Hyak (WA007166) is a semidwarf soft white club winter wheat with resistance to strawbreaker foot rot. It was released to the grain producers in 1988. Hyak is resistant to the local races of stripe rust, leaf rust, and Hyak has good yield potential. The milling and flour characteristics of Hyak are equal to those of other club varieties. Hyak was developed by ARS-USDA and WSU.

Tres
Tres is a soft white club winter wheat. It is a semidwarf with awnlet compact heads, white glumes and straw. Tres has intermediate resistance to stripe rust, leaf rust and powdery mildew. Tres is moderately susceptible to strawbreaker foot rot. It is highly susceptible to flag smut, Cephalosporium stripe, and most races of the dwarf bunt. Tres has high yield potential with a better yield record than other club wheats grown in the area. Tres has heavier test weight than other club wheat varieties. It is less coldhardy than Tyee, and emerges more slowly than Moro or Paha. Tres has typical club wheat milling and flour qualities. Tres was developed by USDA-ARS and Washington State University.

Andrews
Andrews (WA6820) is a white-chaffed, semidwarf hard red winter variety. Andrews has good resistance to snowmold and fair resistance to dwarf bunt and stripe rust. It is susceptible to leaf rust and Cercosporella foot rot. Yield performance out of the snowmold area has been fair. Emergence is typical of a semidwarf. Andrews is somewhat low in flour yield when milled. The bread baking properties of the flour are satisfactory. Andrews was developed by WSU and USDA-ARS.

Batum
Batum is a hard red winter wheat with a white chaff common head. Batum is a semidwarf with shorter straw than Wanser, Hatton or Westin, but the lodging resistance is better than the other hard red winter wheats. The variety emerges equal to Wanser or Hatton. The winterhardiness of the variety is slightly below the other hard red winter wheats. Yield of Batum has been slightly better than Hatton, Wanser or Westin. It is susceptible to dwarf bunt, but is resistant to stripe rust and moderately resistant to leaf rust. The variety is susceptible to Cercosporella foot rot and snow mold. It has acceptable milling and baking quality, but the test weight is 1 lb less than Wanser. Batum was developed by Washington State University and USDA-ARS.

Hatton
Hatton is a hard red winter wheat variety with a white-chaffed common type head. The variety is slightly taller and later maturing than Wanser. It has a higher yield record than Wanser. The variety has better stripe rust resistance than Wanser. It is susceptible to dwarf bunt, snow mold and Cercosporella foot rot. Straw strength, shatter resistance and emergence are equal to Wanser. Winterhardiness is slightly better than Wanser. Milling and baking qualities are similar to Wanser and McCall for bread baking. Hatton was developed by USDA-ARS and Washington State University.

Westin
Westin is a hard red winter wheat variety with a brown-chaffed common head. The variety is taller and has weaker straw than Hatton or Wanser. Westin is susceptible to the races of stripe rust that attack Moro and most club wheats. It has some resistance to leaf rust and is resistant to local races of common and dwarf bunt. It has moderate snow mold resistance. Emergence is excellent. Flour protein tends to be slightly higher than Hatton or Wanser. Milling and baking properties are satisfactory. Grain yields of Westin are somewhat better than Wanser, but usually less than Hatton. Westin was developed by the University of Idaho.

SPRING WHEAT

Dirkwin
Dirkwin is a beardless, white-chaffed, semidwarf wheat released in 1978. It is a very widely adapted variety, yielding well under both droughty and high-producing conditions. Compared to Twin, Dirkwin is similar in plant height, test weight, and heading date. Dirkwin is resistant to powdery mildew, stem and stripe rust. However, Dirkwin is susceptible to prevalent races of leaf rust. The milling and baking qualities of Dirkwin are satisfactory. Dirkwin was developed by USDA-ARS and the Idaho Experiment Station at Aberdeen, Idaho.

Edwall
Edwall was developed at Washington State University and released for Foundation seed production in 1984. Edwall is derived from the cross of an early CIMMYT wheat, Potam 70, and Fielder. It is an awned semidwarf with white chaff variety. It carries the highest levels of resistance to stripe, leaf and stem rust now available in a soft white spring wheat. Edwall has shown a higher yield potential in many tests than Waverly. It is susceptible to mildew and hessian fly. Edwall is tolerant to acid soil toxicity.

Owens
Owens is a semidwarf, awned, stiff-strawed soft white spring wheat developed by USDA-ARS at the Idaho branch experiment station at Aberdeen, Idaho. Owens carries the same resistance to stripe rust present in Dirkwin, but is susceptible to currently prevailing forms of leaf rust and mildew. Owens has high test weight and satisfactory milling and baking properties. Owens yields competitively with other soft white spring wheats when leaf rust is not severe. Seed supplies of Owens are yet somewhat limited. The variety was not released in Washington because of its greater susceptibility to leaf rust than Dirkwin and Waverly.

Penawawa
Penawawa soft white spring wheat was developed by Washington State University and USDA-ARS and released for Foundation Seed Production in 1985. Penawawa is a long awned semidwarf with white glumes. It is a sister line to Edwall and in many respects is similar in appearance but about 1-2" taller in height. It carries a combination of resistances to stripe, leaf and stem rusts similar to that of Edwall. It differs from Edwall by producing grain of 1-2 lbs/bu test weight higher, a fact which is reflected also in its average 5%+ greater average yield. It is moderately susceptible to mildew and susceptible to hessian fly. Penawawa has good lodging resistance and seems more widely adapted than Edwall.

Waverly
Waverly is a semidwarf, white-chaffed, soft white spring wheat developed by Washington State University and USDA-ARS. Waverly has good lodging resistance with considerable straw height for nonirrigated and irrigated spring wheat production. Waverly matures one to three days later than Fielder and about one to five days earlier than Urquie. Waverly is moderately resistant to stripe rust, leaf rust and stem rust. It is moderately susceptible to mildew. The test weight is slightly below Fielder and Urquie but superior to Twin and Dirkwin. The variety has about the same yield potential as Owens. The yields of Waverly are higher than Fielder when stripe and leaf rusts are present. Waverly carries adult plant resistance to stripe rust which becomes effective at a later growth stage than is the case for Urquie. The variety has good milling and baking quality when grown on nonirrigated or irrigated land.

McKay
McKay is a semidwarf hard red spring wheat developed by USDA-ARS at the Aberdeen, Idaho station. In Washington McKay has sometimes shown good overall yield potential, about equal to Wampum. McKay is resistant to stripe, leaf and stem rusts and to mildew.

Wampum
Wampum is a new "tall" semidwarf hard red spring wheat developed by Washington State University and with the collaboration of USDA-ARS. The straw is lodging resistant. Yields are higher than Wared and equal to Fielder under irrigation. It is resistant to leaf and stripe rust. Wampum has excellent milling and bread baking qualities.

WINTER BARLEY

Boyer
Boyer is a 6-row, white-kerneled winter barley variety with rough awns but it does not have the severe "itching" characteristics of other winter varieties. The variety has a high yield record and relatively short, stiff straw with 15 percent less lodging than most other winter barleys. Boyer is slightly more winterhardy than other varieties except Kamiak. Boyer has shorter straw than most other winter barleys. The kernels of Boyer are larger and plumper than other winter barleys. Boyer was developed by Washington State University.

Hesk
Hesk is a 6-row winter barley developed by Oregon State University. Hesk has mid-season maturity and relatively good yield potential, slightly less than Boyer in eastern Washington. It has a plant height, lodging resistance and winterhardiness similar to Boyer. Hesk has a high test weight.

Kamiak
Kamiak is a 6-row winter barley. It has produced high yields in tests. Kamiak has good winterhardiness. Kamiak is mid-tall and lodging can be a problem. The test weight of Kamiak is moderately high. The variety has early maturity. Kamiak does not have small glume hairs which cause "itching" during threshing. Kamiak performs well in eastern Washington. Kamiak was developed by Washington State University.

Showin
Showin is a semidwarf 6-row winter feed barley with a better yield record than Kamiak or Boyer. It is 20 percent to 25 percent shorter than Kamiak or Boyer. It is 27 percent more lodging-resistant than Kamiak, being similar to Boyer. Showin is more winterhardy than Boyer, and is similar to Kamiak. Showin has prostrate growth habit until the jointing stage, which would be an advantage in weed control and soil conservation because of the early and more complete ground cover. Feeding trials indicate Showin is similar to Kamiak and Boyer in nutritional value. Showin was developed by Washington State University

SPRING BARLEY

Advance
Advance is a 6-row spring malting variety. The variety has low or no cold tolerance and, therefore, is susceptible to winterkill which will reduce the problem of volunteer barley in subsequent crop rotations. This is especially important when wheat is grown after barley. Extreme earliness will permit Advance to mature under more favorable conditions. Advance is a short, stiff-strawed variety. Additionally, tests indicate that Advance has a higher feed value for livestock than Steptoe but it yields only 93 percent as much grain as Steptoe. Advance has some susceptibility to mildew, but in trials where this disease has been prevalent, yield losses were not detectable and malting quality was not impaired. Advance was developed by Washington State University.

Andre
Andre is a 2-row, rough-awn spring malting barley with good feed quality for the PNW. It has a nodding head with medium-short stiff straw and good tillering capacity. Andre yields exceed Klages and Vanguard and approach those of Steptoe. At Pullman, Andre is one day earlier than Klages, about the same as Vanguard, and six days later than Steptoe. The variety has good lodging and shattering resistance. The kernels are slightly larger than those of Klages or Vanguard but smaller than the kernels of Steptoe. The test weight is higher than Steptoe. Feeding trials indicate that Andre is better than Steptoe in feed value. Malting barley tests indicated Andre has good 2-row malting barley quality. Andre was developed by Washington State University.

Belford
Belford is a 6-row, hooded or awnless variety of spring barley developed by Washington State University. It is mid-season in maturity and medium tall. The straw is relatively weak. Belford is recommended only for hay and only in eastern Washington high rainfall areas and in central Washington under irrigation.

Cougbar
Cougbar is a 6-row spring barley with rough awns, medium height and good lodging resistance. It has high yield and wide adaptation. Its yield has equaled or exceeded Steptoe's at Pullman, and is about 96% of Steptoe averaged across eastern Washington. Cougbar has plump kernels, high test weight and less winterhardiness than Steptoe. Cougbar's yield, test weight and percent plump kernels have been greater than those of Advance. Cougbar has relatively good nutritional and malting quality. However, Cougbar is not as yet classified as a malting barley, as industry tests are incomplete. Cougbar was developed by Washington State University.

Klages
Klages is a 2-row malting barley adapted to production with irrigation. The variety is not well-adapted to low moisture dryland situations. Klages has stiff straw and the beards are rough. It is mid-season in maturity. The variety has excellent malting quality but does not have as high yield record in Washington tests as other 2-row malting varieties. Klages was developed by the USDA and the University of Idaho.

Steptoe
Steptoe is a 6-row, rough-awned spring nonmalting barley with a high yield record. The test weight is high for a 6-row. Steptoe heads later than most 6-row varieties. The variety has stiff straw with good lodging resistance. The straw is medium-tall. The heads are erect with rough awns. The variety is not acceptable for malting. Steptoe was developed by Washington State University.

OATS

Appaloosa
Appaloosa is a new yellow spring oat developed by Washington State University with more yellow dwarf virus tolerance than Cayuse. Appaloosa has up to 10 percent higher yield performance compared with Cayuse, but slightly lower average test weight. Appaloosa is a mid-season spring oat with straw 1 to 2 inches shorter than Cayuse. It has slightly better resistance to lodging than Cayuse.

Cayuse
Cayuse is a high-yielding, moderately early spring oat recommended in Washington. Cayuse was developed by Washington State University from a selection made at Cornell University. It is a short, pale green variety with open and spreading heads. The straw is strong and resistant to lodging. The kernels are light yellow. Cayuse has yielded 10 to 20 percent more than Park in test plantings. The main weakness of Cayuse is its low test weight compared with that of Park. The test weight of Cayuse has averaged about 35 pounds per bushel in all Washington locations, with 37 for Park. Cayuse has fair tolerance to the most serious oat disease in

yWashington--barley yellow dwarf virus disease, or "red leaf of oats". The yellow dwarf tolerance of Cayuse can be seen mainly in its high yielding ability. Discoloration results after severe attack by aphids carrying the virus. No other disease of consequence has attacked Cayuse at any Washington location since testing began in 1959. Cayuse is susceptible to node blackening and stem break in the eastern part of the United States, but the disease does not affect oat yields in Washington.

Monida

Monida is a new white spring oat developed at the USDA-UI Research Station at Aberdeen, Idaho. Monida yields almost as high as Cayuse and Appaloosa, but has the special advantage of a higher grain test weight under most test conditions and the more desired white grain color. It heads a day or so later than Cayuse, and sometimes is a few inches taller. Its lodging resistance is average for its height. It probably would lodge under irrigation and high fertility. It should carry at least the Cayuse level of tolerance to BYDV, but comparative tests have not been made.

Soft White Winter Wheat Improvement.

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Washington wheat growers harvested 124.6 million bushels of wheat in 1988 for an average yield per acre of 58 bushels. Grain production increased approximately 2 bushels per acre over the average grain yield in 1987. The winter was very mild and precipitation was below normal. Stripe rust was prevalent in some regions and may have reduced yields. Dry land foot rot was prevalent and caused extensive damage. Low temperatures that occurred about the middle of May caused considerable damage over a large part of the wheat region in Washington. Cool weather and timely precipitation helped to make up for the lack of adequate soil moisture in the region.

Nurseries.

Grain yield data from the WSU soft white winter wheat nurseries grown at Pullman (late), Pomeroy, Walla Walla, Ritzville, and Cunningham, Washington is presented in table 1. When the yields were averaged across locations for the past five years Dusty, Lewjain, Malcolm and Madsen (77 bu/a) were the best commercial cultivars. Hyak was the best club variety over this same period. The new line WA007529 (80 bu/a) averaged 3 bushels per acre more than the best commercial cultivar over the past five years.
The Pullman Late nursery (table 1) was sown October 5, 1987. Emergence was in February because of the dry soil conditions. In 1987/88 Oveson (92 bu/a) produced the most grain of the commercial cultivars and Malcolm (91 bu/a) was second. Over the past five years Madsen produced the most grain of the commercial cultivars but WA007529 averaged one bushel per ace more than Madsen. The Pomeroy nursery (table 1) was sown September 18, 1987. In 1987/88 Oveson (57 bu/a) was the highest yielding commercial cultivar. When the yields were averaged over the past 5 years Lewjain (61 bu/a) was the highest yielding commercial cultivar. WA007529 averaged 5 bushels per acre more grain than Lewjain over past five years. The Walla Walla nursery (table 5) was sown November 18, 1987. Madsen (69 bu/a) was the highest yielding commercial cultivar in 1987/88. When the yields were averaged over the past 5 years Dusty (92 bu/a) was the highest yielding cultivar and Hyak (90 bu/a) was the best club wheat.
The Ritzville nursery (table 1) was sown September 3, 1987. Hyak and Lewjain (53 bu/a) were the highest yielding commercial cultivars in 1987/88 and WA007529 equalled their production. When the yields were averaged over the past 5 years Lewjain (58 bu/a) had the highest production of the commercial cultivars and WA007529 exceed Lewjain's average production by one bushel. The irrigated nursery at Cunningham (table 1) was planted October 9, 1987. In 1987/88 Oveson (103 bu/a) was the highest yielding commercial cultivar. When the yields were averaged over the past 5 years Malcolm (111 bu/a) had the highest average grain yield. Daws (106 bu/a) was second leading cultivar for the 5 year period.

Table 1. Yield data (bu/a) on 13 winter wheat varieties grown at five locations in Washington during 1987/88 and the five year average for each variety at each location. The overall average for 1987/88 and for the last 5 years is also presented.

	Pullman Late		Pomeroy		Walla Walla		Ritzville		Cunningham		Average	
	88	5 yr. AVG.	88	5 yr. AVG.	88	5 yr. AVG.	88	5 yr. AVG.	88	5 yr. AVG.	88	5 yr. AVG.
Stephens	71	73	52	53	62	86	37	39	89	97	62	70
Daws	66	72	51	58	68	84	49	56	90	106	65	75
Dusty	84	85	44	59	64	92	48	52	100	99	68	77
LEWJAIN	81	80	54	61	65	86	53	58	100	102	71	77
HILL81	78	80	49	58	67	86	43	49	88	101	65	75
MALCOLM	91	80	54	60	67	88	39	46	101	111	70	77
MADSEN	**84**	**86**	**52**	**60**	**69**	**88**	**51**	**53**	**93**	**100**	**70**	**77**
OVESON	92	82	57	56	68	89	40	37	103	96	72	72
CREW	61	73	50	60	61	83	48	55	89	95	62	73
TRES	81	78	47	57	63	85	44	57	92	95	65	74
HYAK	**81**	**81**	**47**	**59**	**65**	**90**	**53**	**55**	**81**	**94**	**65**	**76**
WA007529	90	87	51	66	66	90	53	59	89	98	70	80
WA007431	84	83	57	61	71	90	50	55	91	96	71	77

Two new lines exhibited good winter hardiness this past winter. They were better than Daws the best winter hardy commercial soft white winter wheat. Both of these lines are being considered for release. WA007431 would be primarily for the areas in Washington where snow mold is a problem. WA007529 has perform well under most conditions except under irrigation.

Table 2. 1988/89 winter survival data on 15 soft white winter wheats grown at Ritzville, WA. The nursery was sown September 3, 1988.

Cultivar	% Survival	Cultivar	% Survival
WA007431	83	Dusty	35
WA007529	75	Malcolm	24
Daws	68	Madsen	23
Lewjain	57	Oveson	21
Moro	55	Hill 81	14
Nugaines	51	Crew	14
Tres	39	Stephens	8
Hyak	38		

Recent Progress in Winter Wheat Genetics

R.E. Allan, E. Haro, L.M. Little, J.A. Pritchett and D.E. Roberts

Developing Winter Wheats for Early Seeding to Control Erosion.

The release of Madsen and Hyak has provided farmers with resistance to the rusts and strawbreaker foot rot. These diseases are generally problems of early sown wheat. Neither Madsen or Hyak have tolerance to cephalosporium stripe which is the other serious soilborne disease which is often serious in early seedings. Our main source of high resistance to strawbreaker foot rot is a French line known as VPM. It is very susceptible to cephalosporium stripe and early observations indicated it might be difficult to breed wheats that have combined resistances to both strawbreaker and cephalosporium stripe. Dr. Diana Roberts conducted a study of several advanced lines to determine the relationship between reactions to these two pathogens. Her study covered 3 years of evaluation of several advanced lines to both cephalosporium stripe and strawbreaker. She was able to show that although VPM was very susceptible to cephalosporium stripe, it was possible to select wheat lines which had high resistance to strawbreaker and effective tolerance to cephalosporium stripe.

Table 1 compares yield results of six promising lines and four varieties. Three lines derived from VPM and Hill 81 were among the most promising and consistently had mean yields comparable to Hill 81 in the cephalosporium trials. They yielded twice as much as Hill 81 under strawbreaker infection. Lines involving VPM, Raeder, and Barbee also had high yield potential under cephalosporium stripe pressure (92 to 99 bu/ac) and had high resistance to strawbreaker (89 to 94 bu/ac). These lines have been placed in advanced trials and are being used as parents.

Table 1. Mean Yields of Lines and Varieties in Cephalosporium and Strawbreaker Trials.

Kind	Cephalosporium 1985	Cephalosporium 1986	Cephalosporium 1986	Cephalosporium Avg.	Strawbreaker, 1987 disease	Strawbreaker, 1987 Control
	Bu/Ac					
VPM/2*H81,D	74	96	106	92	129	123
VPM/2*H81,E	81	96	98	92	124	123
VPM/H81,B	73	94	110	92	118	102
VPM/RDR,A	85	101	93	93	89	93
VPM/RDR,C	76	89	132	99	94	91
VPM/BRB,A	83	91	100	92	90	94
HILL 81	89	109	99	99	59	107
RAEDER	71	84	107	87	38	67
BARBEE	86	98	76	87	40	81
STEPHENS	49	68	74	64	62	119
5% LSD	16	17	20	11	22	27

Development of Special Genetic Stocks and Germplasm Lines of Wheat.

Current USDA-ARS policy emphasizes the development of special genetic stocks and germplasm lines. We have increased the emphasis of our wheat genetics program in this area. Current objectives include the development of: a) Isogenic lines for important morpho-physiological traits. b) Varieties with diverse cytoplasms called alloplasmic lines. c) Lines and populations with unique and/or stable resistance to diseases. d) Stocks that facilitate improved breeding procedures.

Isogenic lines: The 1989 tests include 12,000 F_3 lines of backcross 5 and 6 to Nugaines, Paha, Stephens, Brevor, Luke, and Daws which will be evaluated for transferring three different photoperiod response genes into these cultivars. Photoperiod response has important implications for yield, adaptation, tolerance to frost, and disease response.

Backcross 3 and 6 were made in transferring Rht_3 and Rht_{12} dwarfing genes into Daws, Brevor, Burt, Moro, Marfed, Nugaines and Olympia varieties. When completed, we will then have plant height isolines in several genetic backgrounds for four of the most important dwarfing genes that are found in wheat.

Vernalization response is the third important genetic system that affects wheat growth. We have populations representing backcross 3 in transferring Vrn_1, Vrn_2, and Vrn_3, genes into several genetic backgrounds including Daws, Stephens, Nugaines and Lewjain.

Alloplasmic lines: We have made reciprocal crosses transferring cytoplasms of six *Aegilops* species and four other wheat relatives to Luke, Tres, and Daws. Yield trials are planted at Pullman and Walla Walla this season to determine the effect of these exotic cytoplasms on wheat yield performance and other important agronomic traits. Genetic differences in the cytoplasm of wheat have been shown to play an important role in the expression maturity, coldhardiness, male and female fertility, disease resistance, and yield component expression.

Disease resistance: In addition to developing parental lines with combined resistance to strawbreaker foot rot and cephalosporium stripe, we are placing emphasis on using recurrent selection to combine five sources of tolerance to Barley Yellow Dwarf virus into adapted parental lines. We have 160 F_1 crosses combining tolerance of these sources in all possible combination in the varieties of Daws, Dusty, Lewjain and Tres.

We are using a cytoplasmic male-sterile facilitated nuclear restorer system to achieve recombination among several of the genes for dwarf bunt resistance. This material contains lines which represent all of the known genes for common and dwarf bunt resistance. The populations were allowed to randomly cross-pollinate for two cycles before they were crossed to a Luke-type fertility restorer line. About 6000 F_3 head clumps are being grown this year and will be evaluated for their smut reaction in 1990.

Foliar disease resistance: Although stripe rust remains the main foliar disease, leaf rust, stem rust and powdery mildew often cause serious losses. With the exception of Madsen none of the currently grown SWW wheats have combined resistances to the three rusts and to powdery mildew. Emphasis is being focused on adding rust resistance from several relatives of cultivated wheat including *Triticum dicoccoides*, *T. spelta*, and *Agropyron elongatum*. Other important objectives are to combine adult and seedling resistance to stripe rust in club wheats and to broadening the genetic base of mildew resistance in our populations.

Male sterile stocks: We have 2 more backcrosses to make to complete the transfer of two different genetic male sterility systems into several SWW wheat varieties adapted to the region. We are already exploiting the *T. timopheevi* cytoplasmic sterility system in several recurrent selection projects.

Promising Advanced Lines.

SWW clubs: WA7526 and WA7527 have continued to perform well agronomically. They are multilines that are closely related to Tres. Both are mixtures of wheat lines that differ genetically for resistance to stripe rust and leaf rust. They also have partial resistance to powdery mildew. Their yields have been generally equal to Tres. In 1988, WA7526 had the highest overall yield in the WSU extension trials. WA7526 may have questionable noodle quality, however. Preliminary approval has been obtained for increase of WA7527. It should help reduce the vulnerability of our club wheat production to stripe rust and leaf rust.

WA7621, WA7622 and REA8825 possess the VPM type of resistance to strawbreaker foot rot, have rust and mildew resistance and satisfactory club wheat quality. In the four 1988 USDA-ARS yield trials WA7621, WA7622 and REA8825 had mean yields of 117, 120, and 116 bu/ac vs 111, 100, 112 for Hyak, Tres and Daws, respectively. In 9 WSU yield trials WA7621 and WA7622 both had mean yields of 72 bu/ac vs 67, 70 and 69 bu/ac for Crew, Hyak and Stephens, respectively.

SWW commons: WA7625 which is a sib of Madsen continues to show promise. It was the highest yielding entry in the 1988 Regional Soft White Winter Wheat Nursery. In 13 1988 Washington trials WA7625, Madsen, Stephens, and Lewjain had mean yields of 93, 94, 84 and 91 bu/ac, respectively. WA7625 has somewhat better milling score and cake volume than Madsen.

HARD RED WINTER WHEAT BREEDING AND TESTING

E. Donaldson, M. Nagamitsu and Bruce Sauer

The hard red winter wheat breeding and testing program in Washington is partially funded by the Washington Wheat Commission and is conducted from the Dry Land Research Unit at Lind. The primary objective is to provide Washington hard red winter wheat producers with good quality, consistently high yielding, disease resistant varieties through varietal development and testing of advanced selections and varieties developed elsewhere. The Great Plains yield nurseries, which include selections from Texas to Canada, from public and private breeders are grown at Lind. The Western Regional Hard Red Winter Wheat nursery, which include selections from the western region, including Oregon, Idaho, Utah, Montana, and Washington is grown at five locations in Washington. In varietal development, emphasis is placed on the agronomic characteristics of emergence, lodging resistance and yield performance. The most emphasis in disease resistance is currently being placed on strawbreaker foot rot, stripe rust, leaf rust, dwarf bunt, and snowmold. In breeding for bread baking quality, the challenge is to combine high protein with high flour yield and large loaf volume.

In the hard red winter wheat growing region of Washington the need for adequate straw to aid in the prevention of erosion varies from a demand for more straw than the present varieties to a desire to have less straw to reduce the need for extra tillage. Strong emerging varieties are a necessity throughout the area. In an attempt to provide shorter wheats with good emergence, two semi-dwarfing genes with long coleoptiles are being used in the breeding program. Selections containing the gene from an Omar mutant with exceptionally long coleoptiles and very good straw strength have failed to emerge better than the conventional semidwarf varieties. Crosses are now being made with selections with excellent emergence. The gene from Chinese wheats have not yet been tested in adapted backgrounds.

Blizzard (ID00297) was released by Idaho. Due to questionable quality, Washington did not join the release. Blizzard is a tall, awned, white to tan chaffed cultivar with good snowmold and TCK resistance. Protein content is good. Emergence is better than Weston and winter hardiness is equal to Hatton. Stripe rust resistance is probably adequate for most years. Blizzard's straw strength and yields have been marginal. WA7523 has Departmental approval for release. WA7523 is a high tillering, mid tall, awned, white glumed cultivar with exceptional emerging ability under stress conditions. Its yield record on dry land in the past three years has been excellent. WA7523 appears to have fair snowmold resistance, but poor dwarf bunt resistance. Major weaknesses are poor straw strength, moderate susceptibility to stripe rust and slightly lower flour protein content than Hatton. ORCR8313 (developed by Oregon State University) is an awned, white chaffed semidwarf with good protein content, good stripe rust resistance, and excellent straw strength. Winterhardiness and emergence this past year have been better than Batum, but probably not adequate for most years in the summer fallow areas of Washington. Its yields under dryland and irrigation have been below Batum.

The percent winter survival of soft white and hard red winter wheats are shown in the following table. The nursery at Harrington was seeded September 6 and Connell September 8, both with a deep furrow seeder. Lind Irrigated was seeded September 29 with a double disc seeder. Considerable variation existed within a nursery. Comparison between the soft white varieties and the hard red varieties is not valid since they were grown in separate nurseries.

Table. 1. 1988 - 89 percent survival of soft white and hard red winter varieties at three locations.

	% Survival			
Variety	Harrington	Connell	Lind Irr.	Ave.
Daws	54	36	48	46
Lewjain	52	18	38	36
Dusty	34	5	18	19
Madsen	30	6	10	13
Hill 81	24	1	8	11
Stephens	16	6	1	8
Moro	64	34	35	44
Tres	46	12	18	25
Hyak	43	6	13	21
Hatton	65	80	33	59
Blizzard	78	68	30	59
WA 7523	65	48	33	49
Andrews	65	30	20	39
Weston	60	45	10	38
ORCR8313	45	50	15	37
Batum	33	1	6	13

The 1988 performance of the soft white winter and hard red winter wheats tested under this project are given in the following tables. Direct comparison of the soft white varieties with the hard red varieties is not valid since they were grown in separate nurseries. The nurseries at Horse Heaven, Finley, and the white wheat nursery at Lind, under dryland,were not harvested due to poor stands.

Table 2. Summary of characteristics of winter wheat varieties grown at Lind, 1952 - 88.

Variety	Ave. Plant ht.	Ave. Test wt.	1988 Yield bu/a	Ave. Yield bu/a	Yield % Kharkof	No. years grown	% Protein 1988	% Protein 4 yr ave.
Nugaines	26	61.2		34.6	123	23		
Dusty	24	60.0		28.2	135	5		
Lewjain	26	59.4		30.6	123	11		
John	26	59.9		29.8	114	7		
Stephens	26	58.2		29.7	116	15		
Hill 81	26	59.0		25.8	98	6		
Madsen	25	57.8		24.6	85	4		
Moro	30	58.5		34.1	119	24		
Crew	26	58.2		31.8	126	10		
Tyee	26	58.4		29.6	106	12		
Tres	26	59.9		31.4	119	8		
Hyak	26	57.8		25.5	88	4		
Wanser	31	61.5	26.1	32.3	115	25	13.7	13.8
Hatton	30	62.4	28.2	31.1	126	13	13.9	13.7
Weston	33	61.4	26.0	30.6	123	11	13.6	14.2
Batum	27	60.4	23.4	33.7	133	8	12.8	14.2
Andrews	26	60.3	28.8	28.0	108	7	14.0	13.3
WA 7523	27	60.9	26.4	27.9	115	3	13.2	14.2
Kharkof	33	60.6	21.0	28.3	100	34	14.1	14.0

Influencing 1988 results: Poor stands due to poor seeding conditions; spring drought; late spring frost. White wheat nursery not harvested.

Table 3. Summary of agronomic characteristics of winter wheat varieties grown near Waterville, 1952 - 88.

Variety	Ave. Test wt.	1988 Yield bu/a	Ave. Yield bu/a	Yield % Kharkof	No. years grown	% Protein 1988	4 year ave.
Lewjain	61.9	52.3	45.2	163	7		
Sprague	61.2	51.9	45.1	149	12		
John	61.7	49.9	43.0	156	7		
Madsen	60.2	29.8	29.8	91	1		
Tres	61.6	51.0	35.2	130	4		
Hyak	60.6	22.3	22.3	68	1		
Wanser	59.0	37.2	35.9	114	20	10.0	12.1
Hatton	63.8	58.0	35.7	136	10	9.6	29.4
Weston	62.6	56.0	36.5	130	9	10.4	35.0
Batum	60.4	58.5	38.3	141	8	8.8	34.3
Andrews	60.9	57.5	42.3	153	7	9.5	11.7
WA 7523	62.1	59.9	39.3	153	3	8.8	
Kharkof	61.2	32.6	31.7	100	29	9.4	11.9

Table 4. Summary of agronomic characteristics of winter wheat varieties grown at Connell, 1975 - 88.

Variety	Ave. Test wt.	1988 Yield bu/a	Ave. Yield bu/a	Yield % Kharkof	No. years grown	% Protein 1988	4 year Ave.
Lewjain	61.0	32.4	37.8	127	6		
John	60.9	31.6	37.3	126	6		
Stephens	59.8	33.6	36.0	122	11		
Madsen	60.2	29.8	29.8	111	1		
Tres	61.1	35.7	45.1	132	4		
Hyak	60.6	22.3	22.3	83	1		
Wanser	62.5	33.0	34.5	114	12	10.1	12.9
Hatton	63.4	37.5	38.5	131	11	11.1	13.0
Weston	63.1	31.3	37.5	127	9	10.9	13.3
Batum	60.7	36.4	38.3	129	6	9.2	13.2
Andrews	61.3	30.7	35.9	120	7	10.0	13.2
WA 7523	60.9	37.0	33.6	118	3	9.6	
Kharkof	61.7	26.9	30.2	100	12	10.9	13.9

Influencing 1988 results: Severe drought stress in May and some Sawfly damage.

Table 5. Summary of characteristics of winter wheat varieties grown at Harrington, 1984 - 88.

Variety	1988 Test wt.	1988 Yield bu/a	5 Year ave. bu/a	% Protein 1988	% Protein 4 Year ave.
Nugaines	63.3	33.5	42.0		
Daws	60.9	37.3			
Dusty	62.6	40.1	46.1		
Lewjain	62.7	42.8	47.3		
John	62.4	43.4	43.5		
Stephens	60.8	38.2	44.1		
Madsen	61.8	39.3			
Hill 81	62.1	35.4	43.5		
Tres	62.5	34.8	45.5		
Hyak	61.3	38.1			
Moro	60.7	41.4	45.3		
Batum	61.6	43.1	42.3	9.7	10.9
Andrews	61.9	39.4	37.6	9.0	11.7
WA 7523	62.2	38.3		9.4	9.8
Hatton	63.9	44.0	45.0	10.6	10.9

Influencing 1988 results: Severe drought stress in May. _Fusarium_ (dryland) foot rot.

Table 6. Summary of characteristics of white winter wheat varieties grown at Lind under irrigation, 1984 - 88.

Variety	1988 Plant ht.	1988 Test wt.	1988 Yield bu/a	5 Year ave. bu/a
Nugaines	36	63.6	125.1	92.9
Daws	39	62.1	122.9	
Dusty	36	62.2	127.4	95.0
Lewjain	35	63.2	124.6	92.9
John	37	62.2	105.7	83.7
Stephens	36	60.8	131.3	91.6
Madsen	36	60.9	120.7	
Hill 81	37	61.8	105.5	86.6
Tres	40	62.6	124.0	90.0
Hyak	38	61.5	119.7	86.1
Crew	41	61.7	102.4	81.7
Moro	45	60.2	102.9	71.2

Influencing 1988 results: Late spring frost.

SPRING WHEAT RESEARCH

C. F. Konzak, M. A. Davis, Mark Welter

General

WSU's spring wheat breeding activity is centered at Pullman to gain greater efficiency. Extensive evaluation and screening trials are conducted also in the low rainfall area at the Dry Land Research Unit near Lind, and under irrigation at the Royal Slope experimental farm near Othello. Smaller scale research test plots are conducted via grower cooperation on the Dale Bauermeister farm near Connell (dryland summer fallow), at the Kramer ranch near Harrington (dryland recrop), near Pullman at the Don Quist Ranch (dryland recrop), at the Dwelley Jones Farm near Walla Walla (dryland recrop), and at the WSU Wilkie Research Farm near Davenport (recrop and management trial). Extension-related trials at numerous locations further supplement the research tests.

Uniform yield trials of hundreds of new lines are grown at the three main stations each year, in addition to the one trial, WSU's "Commercial" variety trial, which is used also for demonstrations at several research test locations. The uniform yield trials include Washington State soft white and hard red spring wheat nurseries of up to 60 varieties each, which also are grown at many of the off-station sites, and a varying number of advanced and preliminary replicated trials of both wheat types. Since 1986 several off-station trials were placed on dryland recrop sites in order to evaluate the entries for drought tolerance and *Fusarium* root rot resistance. Nonreplicated seed increase plots, especially of soft white wheats, are usually grown at the Royal Slope farm, as are seed increase lots of advanced materials being prepared for entry into Western Regional trials. A number of special trials are grown only at Pullman. These include the Western Regional Spring Wheat Nursery and the Uniform Regional Hard Red Spring Wheat Nursery (Quist ranch). This group of nurseries, plus crossing blocks with many introduced accessions, supplement the base of germplasm available for cross-breeding.

New Varieties

Descriptions of Edwall and Penawawa are presented elsewhere in this issue.

New Releases in 1989

Currently in Breeder, Foundation seed increase and distribution channels by WSCIA are three new spring wheats:

1. Wakanz (WA7183) - Wakanz soft white spring wheat was developed by Washington State University with cooperation from USDA-ARS. Foundation seed was available for registered seed production in 1989. Wakanz is the first soft white spring wheat cultivar developed for use in conservation tillage production situations where hessian fly damage can be a problem. Wakanz carries gene H_3 for resistance to the hessian fly. Wakanz has moderate to good resistance to the prevailing stripe, leaf and stem rusts. Its stripe rust resistance appears to be of the adult plant type. Wakanz is among the highest yielding of cultivars developed by WSU to date. It has good lodging resistance. It is moderately susceptible to mildew.

2. Spillman (WA7075) - Breeder and foundation seed of Spillman are in production in 1989. Production of quality breeder seed has been slightly delayed due to the discovery of white seed contaminants, requiring

intensive line increase and screening before bulking. Breeder and Foundation seed produced in 1989 should meet purity requirements.

3. Wadual (WA7187) - Wadual is a unique new dual purpose processing quality soft white spring wheat developed by WSU with the cooperation of USDA-ARS. Wadual flour has capability for both leavened bread and pastry production based on extensive testing by the USDA-ARS Western Wheat Quality Laboratory, and cooperative baking trials by industry. Foundation seed was available to seed growers for 1989 planting.

Wadual is the first soft white spring wheat cultivar developed with this capability. Line progeny analyses have shown that the dual processing traits are due to a genetic combination, not a mixture of genotypes.

Wadual combines these properties with good yield potential approximating that of Edwall and Waverly. It has moderate adult plant resistance to stripe, leaf and stem rust and moderate susceptibility to mildew.

Wadual is expected to have a place for use in specialty products including whole wheat products, crackers and in applications replacing hard white wheats. Its unique and superior quality properties allow it to be blended freely in marketing and use channels while improving rather than deteriorating the quality of blends as would a hard white wheat.

4. Other lines - WA7492 and WA7176 continue to be evaluated to provide backup for Wakanz. These lines have a somewhat higher type of stripe rust resistance than Wakanz and have equal yield potential. Samples for possible breeder seeds are being purified.

WA7496 - seed stocks of this higher quality high yield, SWS wheat are being purified.

WA7328 - seed stocks of this hessian fly-resistant HRS wheat are being purified on the possibility of breeder seed production.

Advances in Ongoing Research

Spring wheat research at WSU is adapting to the changes coming about in cropping practices and the problems foreseen to accompany them. Several new procedures already have been applied in the variety evaluation trials, and as capabilities develop, other actions will be taken.

Results from the 1985 "drought year" indicated that we already had high performing, comparatively drought-tolerant wheats in our advanced (state) yield trials, and differences in tolerance to *Fusarium* dryland foot rot. Consequently, a shift was made to grow several WSU State HRS and SWS nurseries at the critical moisture limiting recrop sites near Harrington, Davenport and Pullman to gain better data on variety and genotype performance under anticipated moisture stress conditions. In addition, as funds permit we hope to introduce new instrumentation to aid in gauging plant genotype responses to water deficit conditions during their grain fill period.

With the introduction and evident potential of the dual quality wheats, an increasing emphasis has been placed on the improvement of quality traits in a new cycle of breeding for disease and pest resistance and improved yield. Sources of germplasm for improved noodle quality have also been included in new crosses, and rapid screening for noodle quality is being investigated. The advances made in quality improvement are due in large measure to the dedicated and extensive efforts also by Mr. Gordon Rubenthaler, leader, USDA Western Wheat Quality Laboratory, Pullman.

Shuttle Breeding

Of particular overall significance to growers is that variety development has been greatly accelerated through the 2-crop/year "shuttle breeding" effort developed with the cooperation of the Crops Research Division of the Department of Scientific and Industrial Research in Lincoln (Christchurch) New Zealand. The New Zealand crop season in the southern hemisphere is essentially the opposite of ours. New stripe rust races have appeared in New Zealand, permitting us to select for broader based resistance complementary to our adult plant resistance. However, because of increased costs and budget limitations we have not been able to use this system for the past two years.

New Technology

Another culture - A new biotechnology technique permitting the rapid production (within months) of true breeding lines from crosses has been initiated and already is in a high state of development at WSU. This technology will complement other methods, possibly displacing some in the long run. But most important, the method could greatly expedite variety development at WSU if adequate financial support can be achieved.

We already have identified wheats that have excellent culturability traits. However, several recent WSU soft white wheats produce good yields of embryoids from culture, but regeneration into plants results in a high proportion that are albino (lethals), whereas other accessions (especially HRS types) may produce over 90% green plantlets upon regeneration in culture. These differences are genetically controlled. We must, therefore, screen our germplasm base for culturability in the process of developing the anther culture system for practical applications. Several hundred doubled haploid plants from F_1 combinations of HRS wheats have been produced in spring 1989. Seed from these plants will be increased in summer 1989, then included in preliminary evaluations in 1990.

Soft White Spring Wheats

WSU's "shuttle breeding" program already has been influential on the release of SWS wheats Edwall and Penawawa, and have been especially effective toward the incorporation of a hessian fly resistance base in the breeding populations of the WSU spring wheat program. This project has benefited considerably from the cooperation and input of Drs. J. Hatchett, USDA, Manhattan, Kansas, and Keith Pike, WSU, Prosser, Washington. Wakanz was developed from the early phase of this hessian fly resistance breeding program, and has been released to aid in conservation tillage management. New crosses among soft white wheats involve the introduction of resistances to the hessian fly as a standard, although we are not yet concentrating on use of the H_3 resistance gene. Dr. Keith Pike, WSU entomologist, Prosser, already has begun screening segregating materials for hessian fly resistance, providing for the accelerated development of resistant lines. As this screening program develops, other hessian fly resistant genes will be included in the program. New selections from Dr. Pike's screening were increased in New Zealand in 1987-88. Sub-selections from Wakanz were evaluated for hessian fly resistance and are being increased. Wakanz was recently found to be mixed for hessian fly reaction. The proved lines will be introduced as feasible.

Hard Red Spring Wheats

Considerable progress already has been made also toward the development of hessian fly resistant HRS wheats. Besides building the hessian fly resistance germplasm into breeding populations, we have isolated several high-performing, good quality disease resistant lines from a genetics research cooperation program involving Japanese scientists. This cooperative effort also used the New Zealand increase program, and is the means by which the initial phase of the "shuttle breeding" program was achieved. Selections from crosses among these lines and sources of higher protein and of other semi-dwarfing genes are already in yield lots, and are being evaluated for hessian fly resistance. Yields in 1988 suggest these new lines may be far superior to their parents. The most advanced lines are included in Tri-State Regional Spring Wheat Nurseries. Several lines now are in wide testing. Progress also has been made toward enhancing the protein production capacity of our HRS wheats. Spillman represents a first stage development in efforts to improve grain protein capacity in HRS wheats.

Commercial Variety Trial

The Commercial Variety trial is the spring wheat trial shown at the various Field Days. This trial includes most current varieties and several advanced experimentals from the WSU program, some from the University of Idaho and CIMMYT wheats selected by OSU, as well as lines nearing registration or sale by private breeders.

WSU's hessian fly resistant Wakanz is in Registered Seed production. Hessian fly resistance will be essential when spring wheats are grown extensively under no- or mini-till management systems, or near winter wheats so managed. Of the publicly developed SWS varieties, Edwall will likely be the most commonly grown in 1989, as ample seed supplies are available, and its disease resistance remains adequate. It will gradually be replaced by Penawawa, which produces grain of higher test weight, and which carries higher resistance to stripe rust, wider adaptability, and has a better yield performance record. Landmark and Discovery are two privately developed soft white cultivars. Others are hard red spring types developed largely for the northern Great Plains region. Entries included come from Agripro, Great Plains Seeds, Firstline Seeds, and Western Plant Breeders.

Among the HRS wheats, McKay (ID) appears to be the current best performer next to Wampum. Wampum maintains its stripe and leaf rust resistance, but is highly susceptible to stem rust. McKay is resistant to local forms of all rusts. The new 1988 release, Spillman, should replace most of the Wampum when certified seed is available. New entries have not been evaluated sufficiently for comment.

Locations and Management of Evaluation Trials

With the development of the new WSU spring wheat cone planter cooperatively with the WSU Department of Agricultural Engineering, some major changes in plot technique have become feasible:

1. Row spacing - Tests at Pullman and Lind cooperative with Dr. A. Ciha, USDA (now at Monsanto) showed an average 10% yield advantage for the 6", 12" row spacing. With the 6" spacing there may have been less within row seedling competition at the same seeding rate (lbs/acre) while the closer spacing may have permitted earlier coverage of the soil to reduce

water loss. All spring wheat research program evaluation trials were sown at the close (6") spacing.

2. Cropping - In the past all spring wheat tests were on land fallowed the previous season. This practice continues only where it is necessary to achieve pure seed. Trials at Harrington, Davenport, Walla Walla, and near Pullman were sown on recrop land after winter wheat, winter or spring barley.

3. Fertilizer application - Since 1985 we have tested the application of liquid fertilizer between the seeded rows. Dry starter fertilizer 10N, 13P, 9S is placed with the seed at planting. We believe this practice will simplify the control of weeds and allow better use of fertilizers. However, with hard red spring wheats it may be desirable to shank in the N as NH_4 or urea later in the fall rather than spring, to move the fertilizers deeper into the rooting zone in order to improve grain protein production.

TABLE 1

CHARACTERISTICS OF SOFT WHITE SPRING WHEATS

Name	Origin	Height	Maturity	Awns	Quality rating	Drought tolerance	Dryland foot rot	Stripe rust Reaction	Stripe rust Type	Leaf rust	Stem rust	Mildew	Hessian fly	Irrig.	Adaptation High rain	Adaptation Low rain	Recrop
	(1)	(2)	(3)		(4)	(5)	(5)	(5)	(6)	(5)	(5)	(5)	(5)				
Bliss	USDA-ID	SD	L	Y	S	VS	S	MR	AD	S	R	S	S	Y	N	N	N
Dirkwin	USDA-ID	SD	EM	N	S-	MS	S	R	SP	S	R	S	S	Y	Y	Y/N	?
Edwall	WSU	SD	M	Y	S	MS-MR	MS	R-MR	AD+SP	R-MR	R	S	S	Y	Y	Y	Y
Landmark	FL-ML	SD	M	Y	E	?	?	R	AD+SP	R	R	R	S	Y	Y	Y	?
Owens	USDA-ID	SD	M	Y	E	S-MS	S-MS	R	SP	S	R	S	S	Y	Y	?	?
Penawawa	WSU	SD	M	Y	S	MS-MR	MS	R-MR	AD+SP	R-MR	R	S	S	Y	Y	Y	Y
Wakanz(new)	WSU	SD	M+	Y	S	MS-MR	MS	MR	AD+	R-MR	R	S	R	Y	Y	Y	Y
ID232	USDA-ID	SD	M	Y	E	?	?	R	SP	R	R	R	R	Y	Y	Y	Y
WS1	WS	SD	M	Y	S-	S	?	MR	AD+	MR	S	?	S	Y	Y	N	N
Waverly	WSU	SD	M	Y	S	MS	S	MR	AD	MR	MR	S	S	Y	Y	Y	Y
Treasure	USDA-ID	SD	M	Y	S	?	?	R	SP?	MR?	R	S	S	Y	Y	?	?
Golden 86	WSI	SD	EMC	Y	?	M	?	R	?	?	?	?	S	Y	?	Y	Y
Klasic	NK	SD	E	Y	?	M	?	S	SP	?	?	?	S	Y	?	Y	Y
Sprite	USDA-ID	SD	M	Y	E	S-MS	S-MS	R	SP	S	S	S	S	Y	Y	?	?

TABLE 2

CHARACTERISTICS OF HARD RED SPRING WHEATS

Name	Origin	Height	Maturity	Awns	Protein	Drought tolerance	Dryland foot rot	Stripe rust Reaction	Stripe rust Type	Leaf rust	Stem rust	Mildew	Hessian fly	Irrig.	Adaptation High rain	Adaptation Low rain	Recrop
	(1)	(2)	(3)			(5)	(5)	(5)	(6)	(5)	(5)	(5)	(5)				
Ceres	FL-ML	TSD	EM	Y	Y	?	?	MR	AD+SP?	R	R	R	S	Y	Y	Y	Y
Copper(new)	USAD-ID	SD	M	Y	?	?	?	R	AD+SP?	S	R	R	S	Y	Y	Y	Y
McKay	USDA-ID	SD	M	Y	?	?	?	R	AD+SP	R	R	R	S	Y	Y	Y	Y
NK751	NK	SD	EM	Y	N	?	?	R	AD+SP	R	R	R	S	Y	Y	?	?
Spillman(new)	WSU	SD	M	Y	Y	?	?	R	AD+SP	R	R	R	S	Y	Y	Y	Y
Tammy	WS	SD	M	Y	?	?	?	R	AD+SP?	R	R	R	S	Y	Y	Y	Y
Telemark(new)	Agripro	SD	EM	Y	Y	?	?	MR	AD	?	?	?	S	?	?	Y	Y
Wampum	WSU	TSD	LM	Y	N	?	?	R	AD+SP	R	S	R	S	Y	Y	Y	Y
WPB906R	WPB	SD	EM	Y	Y	?	?	R	AD+SP	R	R	R	S	Y	Y	Y	Y
Yecora Rojo	Cimmyt-CA	SSD	E	Y	Y	?	?	MS	?	MS	R	R	S	Y	N	N	N

Definitions (1) FL-ML = First line Seeds, Moses Lake; WS = World Seeds; WSI = Wheat Specialties Inc, Bozeman, MT; M = medium; E = early; (EM = early to moderate maturity, etc). (4) Excellent/Satisfactory. NK = Northrup-King. (2) SD = (5) S = susceptible; R = resistant; M = moderately; V = very. (6) AD = semidwarf; SSD = Short semidwarf; TSD = tall semidwarf. (3) Late/ adult plant, non-specific; SP = race-specific resistance.

TABLE 3

1988 COMMERCIAL SPRING WHEAT TRIAL #46

	Yield Data Bushels per Acre			Test Weight Data Pounds per Bushel			Protein Data Average Protein %		
	Pullman	Lind	Royal Slope	Pullman	Lind	Royal Slope	Pullman	Lind	Royal Slope
VARIETY (WHITE)									
Fielder	71.6	30.9	108.6	59.6	60.9	64.2	8.9	14.0	10.4
Dirkwin	95.8	27.0	107.0	58.7	57.0	61.9	11.7	15.1	10.0
Waverly	86.1	30.8	106.0	59.2	60.1	63.2	13.0	13.5	10.0
Landmark	87.8	25.8	103.5	61.3	60.3	65.0	12.5	14.8	10.3
Edwall	86.3	27.6	109.9	58.7	58.8	63.7	11.5	12.9	10.0
Aberdeen Sel.	92.9	28.3	101.2	60.0	59.7	62.2	12.0	14.9	10.3
Treasure	98.0	31.9	124.5	60.9	61.3	63.9	11.8	13.4	11.2
Bliss	86.2	31.9	115.8	59.0	60.1	63.4	12.4	13.1	9.8
Penawawa	85.4	28.3	115.1	60.4	59.0	62.8	12.1	14.1	9.3
Wakanz	96.6	27.3	115.8	62.0	59.5	64.3	11.9	13.5	10.2
PI506355	97.4	31.2	118.7	58.9	57.9	62.5	11.8	13.5	10.7
Wadual	90.9	26.1	108.9	62.9	61.1	64.9	11.7	14.5	13.1
Golden 86	88.5	23.3	100.9	64.8	61.5	66.0	13.0	16.3	12.8
Klasic	96.6	22.8	105.0	63.8	61.2	66.9	12.4	16.6	12.2
WPB68117	88.9	27.0	114.8	61.6	61.0	64.5	11.9	14.6	12.0
VARIETY (RED)									
Yecora Rojo	85.8	20.4	101.7	63.3	60.8	66.3	13.2	17.3	13.4
Wampum	81.6	34.0	118.2	62.3	60.0	64.5	12.6	15.3	13.6
McKay	89.3	30.4	112.6	61.7	61.6	64.8	13.1	15.2	12.1
Ceres	88.1	23.4	113.5	63.0	60.5	65.1	13.5	15.9	12.0
First Line #9	86.3	24.1	111.0	64.2	62.4	66.8	12.7	15.3	13.0
Nomad	93.6	25.7	111.1	62.7	60.9	64.9	14.1	17.0	13.8
GP007139	77.4	16.4	98.6	61.2	60.4	65.3	14.9	17.6	14.3
Nordic	86.2	27.7	111.8	63.2	62.2	65.7	13.3	17.4	12.6
Butte 86	76.4	25.1	95.0	61.7	61.5	64.8	14.9	17.8	15.1

TABLE 3 (cont.)

	Yield Data Bushels per Acre			Test Weight Data Pounds per Bushel			Protein Data Average Protein %		
	Pullman	Lind	Royal Slope	Pullman	Lind	Royal Slope	Pullman	Lind	Royal Slope
NK751	80.8	29.5	118.2	59.2	59.4	65.3	13.7	15.0	13.1
Copper	86.9	17.7	110.2	61.5	59.5	64.7	14.0	17.0	13.4
SD002961	89.2	25.7	111.2	61.7	60.5	64.5	13.2	16.5	15.0
Spillman	81.7	24.8	109.9	61.3	59.7	64.7	13.7	17.1	13.5
WA007326	82.3	25.5	106.5	61.6	60.1	63.9	13.5	16.7	13.1
WA007493	82.5	28.8	115.6	60.9	60.1	65.6	12.8	15.4	12.4
WA007494	82.2	28.0	118.8	61.2	59.2	65.5	12.6	14.8	12.4
WPB00906	92.0	22.9	98.3	61.5	60.3	64.5	13.4	17.6	13.6
WPB00926	92.7	23.2	104.5	62.2	60.4	64.7	13.2	17.5	14.1

BARLEY BREEDING AND TESTING IN WASHINGTON

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J. S. Cochran and J. A. Clancy

Production

Barley production in 1988 in Washington was approximately 840,000 tons (35 million bushels) from 580,000 acres. The state average yield was about 1.4 tons/acre (60 bushels/acre). Washington was the third largest barley producing state in the U.S. Of the top six barley varieties grown in 1988, five were WSU releases. In rank order, the top six were Steptoe, Boyer, Kamiak, Harrington, Cougbar and Showin. The planting projection for Washington for 1989 indicates that there will be about 500,000 acres of barley.

Objectives

The overall objective of the barley improvement program in the state of Washington is to develop high yielding, stiff-strawed agronomically acceptable spring and winter varieties that are adapted to the different barley producing areas of Washington and that have superior quality. Spring barley is emphasized in the program. The winter barley varieties need to be hardy enough to survive most winters with little or no damage. One major objective in both winter and spring varieties, is to develop lines which meet high quality malting standards and also have superior feeding qualities. These multipurpose varieties would meet flexible market demands for Washington grown barley.

The program involves the development of winter and spring, 2-row and 6-row varieties at Pullman with selection and testing at the Lind Dryland Research Unit, the Mielke Farm near Harrington (winterhardiness), and the Royal Slope Research Unit (irrigated). Other major test sites are at Walla Walla, Pomeroy, Harrington, Davenport (Wilke Farm) and Connell. Dusty, Lamont, Creston, Deep Creek, Reardan, Bickleton, Goldendale, Mayview, Clyde, Anatone, St. John, Uniontown, Fairfield and Farmington are additional extension test locations. The cooperation of B. C. Miller, C. F. Konzak, C. J. Peterson and many growers in the testing effort is gratefully acknowledged.

An additional objective is to measure variety response to various cultural practices. The effects of no-till and nitrogen levels has been or are being investigated at Pullman.

Results

The new varieties developed at WSU are described in front of the brochure under recommended barley varieties for the state of Washington. Yield results of released cultivars are summarized in the tables below along with newer high yielding selections.

Spring Barley

Spring barley performance is presented in Tables 1-5. Although Steptoe continues to be a high yielder, WSU's newest 2-row and 6-row releases, Andre and Cougbar, respectively, have performed well at several locations (Tables 1-3). Several advanced breeding lines have performed quite well especially the 2-row WA8771-78, which is a candidate for release. The performance of selected varieties and lines in the annual cropping (planting on recrop ground) experiment are presented in Tables 3 and 4. Spring barley performance of selected varieties and lines at Lind are presented in Table 6. WA8771-78 again performed well here indicating adaptation to a broad range of conditions.

In general, 2-row barley tends to have broader adaptation than 6-row barley in eastern Washington. At least 2-rows tend to do better than 6-rows in dryer environments [Tables 1 (Pomeroy), 3 and 4 (Davenport, Connell), 5 (Lind)]. The 6-rows tend to do best in the higher rainfall areas, for example, Cougbar at Pullman and Walla Walla (Table 1). Steptoe is an exception, which still does well in most environments it is grown.

Winter Barley

Winter survival was the major issue in this 1988-89 winter. Most locations north and west of Pullman were severely affected. Our winterhardiness screening trail on the Mielke Farm near Harrington had 100% kill. The Lind nurseries were 100% lost. Little or no winter kill occurred at test sites at Pullman and to the southwest. Winterhardiness was not as big an issue last year (87-88) as was emergence through the persistently dry fall. Spotty stands were common, and where late emergence occurred, growth stage and maturity differences were great within a field or plot. This must be kept in mind when reviewing the 1988 data. Winter barley performances is presented in Tables 6-9. The major varieties produced in Washington (Boyer, Kamiak, Showin, Hesk) are compared with newer breeding lines and WA1574-77.

WA1574-77 has been proposed and accepted for release as a new winter barley cultivar. It's yield performance has been consistently high over environments (Tables 6, 8, 9). Its test weight, kernel plumpness and protein levels are comparable with the other cultivars currently grown. Its plant height and lodging percentage is slightly less than the other cultivars except Showin. Its maturity is similar to Boyer and Hesk and later than Kamiak. WA1574-77's winterhardiness is comparable to Kamiak.

Table 1. SPRING STATE DRYLAND NURSERIES

VARIETY	YIELD PULL-MAN	POM-EROY	WALLA WALLA	AVERAGE	REL.TO STEPTOE	PULLMAN TEST WT	PLUMP	HT	LODG-ING
	-------------LB/A-----------				-%-	-LB/BU-	-%-	-IN-	-%-
6-ROW	9 Years, 1980-88		27 LOC-YR						
Cougbar	4950	2970	3720	3880	98	51	76	36	15
Steptoe	4940	3380	3660	3990	100	49	89	36	31
Advance	4410	3020	3480	3640	92	48	71	33	15
Morex	3560	2450	2850	2950	73	51	82	41	30
2-ROW	8 Years, 1981-88		24 LOC-YR						
8771-78	4780	3290	3360	3810	100	53	89	34	25
Steptoe	4690	3280	3490	3820	100	49	89	35	26
Clark	4460	3070	3420	3650	96	53	88	35	27
Andre	4370	3360	3400	3710	97	53	72	33	25
Klages	4370	3000	3240	3540	92	52	78	35	25

Table 2. SPRING BARLEY STATE NURSERIES, 1988

	Yield							Pullman 2 Year Averages (87-88)			
Variety	Dryland Average	Pull- man	Pom- eroy	Walla Walla	Daven- port	Royal Slope*	Total Average	Test wt.	plump	Height	Lodg- ing
	lb/a							lb/bu	%	in	%
6-Row											
13352-85	3890	5160	2760	4050	3570	5460	4200	49	73	38	17
Steptoe	3870	4810	2890	4500	3290	5960	4290	47	72	39	52
13375-85	3830	5500	2480	3840	3510	4940	4050	50	80	39	10
11136-83	3650	4540	2630	4150	3260	5050	3930	49	80	33	0
Cougbar	3570	4720	2320	4110	3110	5120	3880	48	61	39	25
10217-83	3560	5100	2760	3500	2900	4800	3810	50	90	36	0
12809-83	3420	4680	2210	3540	3230	4970	3730	47	67	39	22
2-Row											
7552-83	4300	6040	3560	4460	3130	5190	4480	52	77	38	62
9448-83	4220	6570	3330	4010	2960	4580	4290	49	76	37	25
Steptoe	4190	5440	3470	4720	3120	5690	4490	47	87	38	66
8771-78	4050	5800	3350	3820	3210	4230	4080	51	86	37	63
16277-85	4020	6590	2650	4110	2740	5020	4220	50	87	36	27
9029-84	4010	6300	3230	3460	3030	4810	4170	51	89	36	29
Harrington	3990	6060	2990	3780	3130	5610	4310	53	86	35	24
9035-84	3970	6220	2980	3910	2780	5170	4210	52	90	35	20
13654-84	3830	5920	3290	3520	2590	4480	3960	52	89	32	0
Andre	3810	5620	3160	3650	2820	4690	3990	52	59	36	36
Klages	3610	5580	2810	3240	2810	3970	3680	50	68	36	57
Clark	3570	5070	2950	3740	2530	4430	3740	52	48	38	69

*Irrigated

Table 3. SPRING BARLEY ANNUAL CROPPING, EXPERIMENT 4 YEAR YIELD AVERAGES, 1985-88.

Variety	12 Loc-Yr Average	Pullman	Davenport	Connell
8771-78	2960	4150	2440	1920
Steptoe	2900	4790	2320	1590
Clark	2890	4200	2560	1920
Andre	2710	4140	2180	1820
Cougbar	2670	4540	1850	1630

Table 4. SPRING BARLEY ANNUAL CROPPING EXPERIMENT*, 1988 YIELDS

Variety	Row Type	Yield Average	Pullman	Davenport	Connell
		---lb/a---			
7773-83	2	2710	4090	2380	1660
9029-84	2	2710	4620	1870	1650
Clark	2	2640	3620	2810	1500
8771-78	2	2570	3960	2190	1560
10217-83	6	2520	4640	1540	1360
Steptoe	6	2450	4380	2130	850
Bowman	2	2420	3990	2660	610
Andre	2	2370	3320	2440	1360
Cougbar	6	2230	4140	1540	1000

Nurseries were also grown at Pomeroy and Harrington, but the data are unreliable due to excessive variability.

Table 5. SPRING BARLEY DRYLAND NURSERIES AT LIND

Variety	5 Year Averages			1988		
	Yield	Test Wt.	Plump	Yield	Test wt.	Plump
	-lb/a-	-lb/bu-	-%-	-lb/a-	-lb/bu-	-%-
Clark	1990	51	61	2680	52	66
8771-78	1980	40	70	2240	52	74
Steptoe	1950	47	79	2420	48	78
Cougbar	1760	49	50	2270	50	44
Andre	1760	48	33	1970	52	37

Table 6. WINTER BARLEY MULTIPLE YEAR YIELD AVERAGES

Variety	Pullman 9 Yrs.	Pullman 6 Yrs.	Pomeroy 4 Yrs.	Walla Walla 4 Yrs.	23 Loc-Yr Average
	---lb/a---				
1574-77	5410	5310	4790	5080	5220
Hesk	5190	5210	4810	5080	5110
Showin	5110	4410	3940	4550	4630
Boyer	5100	4900	4400	5090	4920
Kamiak	4710	4290	3360	4560	4340
Schuyler	4640	4500	--	--	4580**

** 15 Loc-yrs. for Shuyler

Table 7. WINTER BARLEY AGRONOMIC PERFORMANCE, PULLMAN, 6 Yrs. (1983-88)

Variety	Yield	Test Weight	Plump Kernels	Plant Height	Lodging
	-lb/a-	-lb/bu-	-%-	-in-	-%-
2607-80	5670	48	79	35	0
2554-81	5480	50	49	36	0
1574-77	5310	49	66	34	1
Hesk	5210	49	63	36	5
Boyer	4900	49	70	36	2
Schuyler	4500	51	60	38	3
Showin	4410	48	58	30	0
Kamiak	4290	51	68	40	30

Table 8. WINTER BARLEY YIELD AVERAGES, 1988

Variety	Yield				
	Average	Pullman	Walla Walla	Davenport	Lind Irrigated
1727-84	<u>4550</u>	2850	<u>5950</u>	<u>4740</u>	4650
1574-77	<u>4480</u>	<u>3360</u>	5330	3980	<u>5240</u>
Hesk	4370	2930	5000	<u>4620</u>	4930
2607-80	4220	<u>3330</u>	<u>5400</u>	3400	4760
Showin	4020	2950	4420	3650	<u>5060</u>
2554-81	4000	3200	4930	3670	4180
Boyer	3970	2900	4950	3380	4640
Kamiak	3853	2660	5030	4090	3630

Table 9. WINTER BARLEY EXTENSION NURSERY YIELD AVERAGES (1986-88 & 1988)

Variety	Averages 27 Loc-Yr.	Averages 1988	Asotin 3 Yr.	Asotin 1988	Mayview 3 Yr.	Mayview 1988	Dusty 3 Yr.	Dusty 1988
	lb/a							
1574-77	4340	4440	3380	2760	4650	4300	3800	3570
Hesk	4170	4100	3280	2870	4060	4280	3690	2980
Boyer	3800	3920	3200	2680	4030	3840	3230	3210
Showin	3700	3740	2790	2250	4150	3920	3380	3350
Kamiak	3510	3520	3190	3370	3730	4080	2750	2430

Variety	St. John 3 Yr.	St. John 1988	Farmington 3 Yr.	Farmington 1988	Fairfield 3 Yr.	Fairfield 1988	Lamont 3 Yr.	Lamont 1988	Reardan 3 Yr.	Reardan 1988	Wilbur 3 Yr.	Wilbur 1988
1574-77	6270	5500	4560	3550	4530	4470	3070	3260	4020	6370	4740	6170
Hesk	5920	5010	4290	3410	4390	4320	3730	3140	3770	5760	4400	5140
Boyer	5590	4620	3830	3340	4170	3900	2980	3050	3590	5970	3620	4660
Showin	5480	5330	3910	2630	3840	3720	3190	2910	2880	4850	3690	4720
Kamiak	4570	4410	3490	2750	4010	3660	3010	3010	2820	4290	3980	3710

TRITICALE

C.J. Peterson, D.F. Moser, K. Hinnenkamp, and V.L. De Macon

Early triticale had many undesirable characteristics such as: low yield, shriveled grain, poor seed set, and excessive plant height. Plant breeders have made considerable progress in improving triticale in the last 10 years. New cultivars are similar to wheat in grain production and the bushel weight although still low (approximately 50 pounds per bushel) has been improved. Seed dormancy and head shattering characteristics of triticale is similar to wheat. Therefore triticale does not present the same volunteer problem as rye.

Cultivars.

Both winter and spring triticale cultivars have been developed for production in the Pacific Northwest.

Winter Triticale.

Flora, a winter triticale, was developed and released from the cooperative USDA/Agricultural Research Service - Oregon State University triticale program. Flora is a high yielding, semidwarf triticale that has a very low bushel weight (approximately 40 to 45 pounds per bushel). Plant height of Flora is similar to that of the semidwarf wheat cultivar Daws. Flora, like most triticale cultivars, is quite susceptible to Cephalosporium stripe.

Spring Triticale.

Grace (also known as Palouse) is a spring triticale that was developed (selection identified by USDA/Agricultural Research Service - Washington State University program) by the Jenkins Foundation in California. Grace is a mid-tall (38-45 inches) triticale with good yield potential. It has some tolerance to freeze damage and has been grown at Pullman, Washington from both fall and spring seedings. The kernels of Grace are quite shriveled and therefore the bushels weights are about 10 pounds below that of wheat.

Whitman (VH080011) was developed and released from the cooperative USDA/ARS - Washington State University triticale breeding program. It is a spring triticale but will survive the winters at Pullman, Washington, if adequate snow cover occurs during the cold weather. Whitman must be seeded early in the spring because it has a short vernalization requirement and will not head properly from a late spring seeding. It is resistant to the local races of stripe rust and leaf rust. Whitman has a good grain yield potential from both winter and spring plantings. It is approximately 15 inches taller than Daws and has a 6 to 10 pound lower bushel weight. Whitman heads earlier than Daws but it matures about the same time. Protein of Whitman is 1 to 2 percentage points above that of the soft white winter wheat cultivars.

The spring triticale Juan was (developed by CIMMYT and University of California at Davis) released to the growers in California in 1984. Juan has performed quite well in the Pullman nurseries. Juan is a mid tall (38-45 inches) triticale and has a very good yield potential. Bushel weight and protein content of the grain is quite similar to that of Whitman. Unlike Grace or Whitman, Juan does not respond to photoperiod and it may head in the fall from an early seeding (August or 1st part of September).

There are a number of good private triticale cultivars available that we have not tested.

Tables 1 and 2 contain the grain yield data on triticales grown from a fall and spring seeding at Pullman for the past few years. Whitman has done as well from a fall seeding although it's grain production was lower than that of Juan the past two years. Juan and Whitman have perform well from an early spring seeding. Juan can be seeded later in the spring than Whitman.

Table 1. Grain yield data (bu/a) for two winter wheats and three triticales grown for seven years at Pullman, WA.

Cultivar	1981	1982	1983	1984	1985	1986	1988	Avg.
Daws	92	75	79	90	33	56	48	68
Stephens	116	88	83	75	32	34	53	69
Grace	102	37	81	67	40	39	80	64
Whitman	108	102	108	106	46	47	81	
Juan	131	60	110	77		61	71	
Flora					51	56	57	

Table 2. Yield data (Bu/a) on two spring wheats and Three triticales grown in Pullman, Washington for five years.

Cultivar	1983	1984	1985	1986	1988	avg.
Owens	40	57	43	49		
Waverly	46	56	43	32		
Grace	31	51	18	38	57	38
Whitman	46	60	39	34	46	45
Juan	47	69	43	39	66	52
Edwall					48	
Penawawa					51	

For further information on Triticale see the Pacific Northwest Bulletin Number 331.

SUMMARY OF ACTIVITIES OF THE USDA WESTERN WHEAT QUALITY LABORATORY

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The milling and baking quality of 3443 experimental wheat germplasm lines (F_5 and later) grown in the western states in the crop year 1987 were evaluated. These included 793 from WA, 681 (OR), 19 (ID), 982 (CA), 106 from western regional nurseries, 149 commercial breeders, and 713 from other researchers, export cargos, and harvest survey projects. Evaluation criteria used to determine acceptable quality were standard tests for flour yield, protein, ash, color; cookie diameter, loaf volume and bread crumb grain; dough mixing requirements and water absorption; Japanese sponge cake volume and score; and Udon noodle yield and texture. About 25% of these samples were judged as having promising overall quality to fit their proper market class. Studies included materials developed for snowmold, dwarf bunt, foot rot and other disease resistance as well as various crop management practices and salinity stress tolerance. These represent new germplasm with potential improvement for both agronomic production hazards and desirable quality for domestic and export markets. Results were provided to each cooperator, as completed.

In cooperation with a grant from the PNW Grains Council the milling and baking evaluation were made on commercial composites representing the wheat crop (1987) of WA, OR, and ID. The data was used in their marketing brochures.

In cooperation with U.S. Wheat Associates, Inc., we again participated in a Western White Export Cargo analysis project. Three sets of samples (55) were collected from out-going cargos. The object of the cargo sample project was to follow the end-use qualities of export shipments through the marketing year. Results show a high degree of uniformity.

In cooperation with the PNW Grains Council, 14 advanced experimental wheat selections were pilot milled and sent to a group of collaborators for evaluations. These include 4 mills in Japan, 2 in Korea, 1 in The Philippines, 1 in Morocco, 1 in Egypt, and 11 local milling and baking firms. Final publication of all collaborator results were assembled and published as the 17th Annual Report-1987 Crop-PNW Grains Council Collaborator Test, July 1988.

In cooperation with Nisshin Flour Milling Company, and U.S. Wheat Associates, Tokyo, we evaluated 28 soft white wheats which represented the current varieties. These samples were collected with the variety identity preserved at sites in OR, ID, and WA. The objective was to determine the variability in functional baking quality of Japanese products within a variety and among locations. This was the second year of a 3 year study.

The milling and baking properties of an additional 1316 F_4 early generation samples from the 1987 crop breeding programs were also evaluated. These experimental wheats were crossed to develop resistance to snowmold, foot rot, dwarf smut, rusts, and adaptability to various crop management practices, and represent all classes grown in the region. Tests used to characterize end-use quality were flour yield, break flour yield (soft wheats), kernel hardness, flour protein, mixograph, water absorption and dough properties, and alkaline water retention capacity. About 42% (552) were scored as promising to meet the overall quality of their market classes. About 1,000 micro (10g) F_3 samples were also evaluated for milling quality. Crosses made to germplasm sources for sprout resistance were analyzed for alpha-amylase activity.

BREEDING, DISEASES AND CULTURE OF DRY PEAS, LENTILS, CHICKPEAS, AND AUSTRIAN WINTER PEAS

F. J. Muehlbauer, S. C. Spaeth, J. L. Coker, and R. W. Short

Dry pea, lentil, chickpea and Austrian winter pea research is conducted in the Palouse region of eastern Washington and northern Idaho. New lines, cultivars and breeding populations are tested in these areas to identify plant types with multiple pest resistance, efficient water-use, stress resistance, yielding ability, and quality. The principal areas of research in each of these crops is as follows:

Dry Peas: The goals of the research program on dry peas include improved quality, mostly better color, and improved yields. Root diseases of peas caused by a complex of several organisms are a major reason poor yields have been common to the area. Most of our efforts have been in identifying resistant lines for use as parents, hybridizing the resistant lines with commercial cultivars, and screening the resulting populations for root rot-resistant segregants with good plant type, good color qualities, and adaptability. Quality tests for resistance to seed bleaching and for adaptability to reconstitution and canning are also conducted. Because pea enation mosaic virus and pea leaf roll virus have become extremely serious on peas and lentils in recent years, we have started screening for resistance in the field and greenhouse. Good resistance is available in peas, and we have recently identified resistance in lentils to pea enation mosaic virus. The goal is to incorporate resistance to these viruses into new cultivars.

Rates of water uptake in germinating seeds may influence emergence rates and susceptibility to root rots. We have devised new ways to measure stresses in seeds. Lines are being tested for differences in water uptake rates and imbibitional stresses to determine whether these traits can be used in pea, lentil and chickpea improvement.

Variations in leaf morphology in peas are being studied to improve standing ability and reduce foliar disease infection. The semi-leafless type with increased tendrils appears to hold particular promise for reducing foliar disease and maintaining yields that are equal to normal plant types. Future germplasm improvement efforts are being directed toward developing virus resistant semi-leafless types. The afila or "semi-leafless" type has particular promise for a yellow pea type because the reduced foliage allows better light penetration to the pods and results in bright yellow peas. Also, the reduced leaf area hastens maturity.

Varieties of peas developed are as follows:

'Alaska 81' was released to growers in 1984. The cultivar is early to flower (10th node), early to mature, and has excellent seed quality traits including dark green color and resistance to seed bleaching. Alaska 81 has resistance to Fusarium wilt race 1 and is tolerant to pea root rot. Alaska 81 is immune to pea seedborne mosaic virus.

'Garfield' is resistant to Fusarium wilt race 1, is larger seeded, and has a longer vine habit when compared with most Alaska strains. Garfield flowers at the 14th node and has tolerance to pea root rot, two factors which delay maturity about one week when compared with most Alaska strains.

'Tracer' is a small-sieve Alaska type that is higher yielding than most other small-sieve types. Other major improvements of Tracer include greater plant height; a reduced susceptibility to seed bleaching; and resistance to *Fusarium* wilt race 1. The increased height of Tracer improves harvesting ease on the ridges where poor vine growth has been a problem. Tracer tends to set triple pods at one or more of the reproductive nodes.

'Umatilla' When compared with Latah, Umatilla is about 7 inches shorter and 13% higher yielding. Umatilla sets double pods compared to the single podding habit for Latah. The seeds of Umatilla are larger and have averaged 18.7 grams per 100 seeds compared to 17.1 for Latah. Seeds of Umatilla are bright yellow and represent a significant improvement in seed quality when compared to Latah in which the seeds have an undesirable green cast.

Lentils: Current objectives in lentil breeding are toward developing an early maturing 'Laird' type and to develop a small red variety from material recently collected in Turkey. Laird is a large-seeded non-mottled variety developed for use in Canada; however, Laird is somewhat late maturing and, on the average, lower yielding than 'Chilean 78' or 'Brewer' when grown in the Palouse. While Laird's total biomass production is large, its seed production falls behind. An early maturing Laird type, 'Palouse', was recently released and is now available to growers.

Varieties of lentils developed are as follows:

'Brewer' consistently has been the highest yielding lentil variety in yield trials. The variety has averaged about 300 pounds per acre more than Chilean and is larger seeded. Brewer is earlier to flower and mature and matures more evenly.

'Redchief',a variety released in 1978, has shown a consistent yield advantage over Chilean. Redchief has red cotyledons and is now used to produce decorticated red lentils.

'Chilean 78' is a composite of selections made from common Chilean lentil seed stocks and, therefore, performance is identical to that expected for Chilean. The primary advantage of Chilean 78 is the absence of vetch-type rogues, particularly those rogues that have seeds similar in size, shape and color to lentils. Chilean 78 has largely been replaced by Brewer.

'Emerald' A bright green lentil with distinctively green cotyledons, has performed well in yield trials. Emerald is a specialty type lentil because of its distinctive green cotyledon color. The variety stays somewhat green at maturity and therefore must be closely followed in order to avoid excessive seed shattering.

'Palouse' Released in 1988 is a large-seeded yellow cotyledon lentil that is similar in size to the Canadian Laird lentil. However, Palouse is earlier to mature and is comparable to Brewer for yield. Palouse also has seeds that are free of mottling.

'Crimson' is a small red lentil that was recently approved for release by the variety release committee. It is expected that Crimson will be officially released this year. Crimson has small brown seeds with red cotyledons. The variety is a "persian" type typical of the lentils grown in the Middle East and northern Africa. The variety is well adapted to intermediate rainfall zones (15-18 inches annually) and therefore could become an alternative crop to wheat in those areas. Expected yields in those areas would be from 750-1000 pounds per acre. Marketing of small red lentils will depend upon availability of equipment for decortication and splitting.

Chickpeas: (Garbanzos) are grown throughout the world in similar environments to those where lentils are grown. The Palouse environment seems well suited to chickpeas and very favorable yields have been obtained. Varieties and breeding lines have been obtained from sources both national and international and have been evaluated for yield potential and seed quality. Cultural practices have included: (1) seeding rates-row spacing, (2) seed treatments, and (3) *Rhizobium* inoculation have been completed. There are basically two types of chickpeas: the "Kabulis", with large cream-colored seeds and the "Desis", with smaller seeds that are variously pigmented. Kabulis represent less than 20% of the world's production of chickpeas; the remainder are Desi types. The Desis are grown primarily on the Indian subcontinent and parts of Ethiopia; whereas, the Kabulis are grown primarily in the Mediterranean basin and North and South America.

Varieties of chickpeas developed are as follows:

'Tammany' This selection has a unifoliate leaf structure which differs from the fern leaf structure that is typical of most chickpea cultivars currently in use. Tammany is earlier to mature and has larger seeds when compared to "UC-5"; the commonly grown cultivar in the region. Seeds of Tammany average 58 grams per 100 seeds compared to 52 grams from UC-5. The uniformly large light cream-colored seeds of Tammany are highly desired by domestic processors and by exporters.

'Garnet' This line originated as a plant introduction from Ethiopia that was mass selected for uniformity. Garnet has produced yields that were equal to or better than other Desi lines. Garnet matures in about 110 days from planting. The seeds are reddish-tan, uniform in size, and weigh 16.4 grams per 100 seeds.

The current problem of Ascochyta blight on chickpeas in the Idaho-Washington area has prompted research on identification of resistant lines. Resistance to blight is available; however, the resistance is associated with late maturity and small-medium seed size. We currently have underway a program to incorporate the resistance into more acceptable types. The breeding material being tested this year is in the F_3.

Austrian Winter Peas: We recently have taken over the Austrian winter pea breeding program and have set a number of objectives including: 1) identification and incorporation of resistance to Aphanomyces root rot into winter hardy Austrian types, and 2) the development of types with high biomass production and high yields that can be used for several purposes including green-manuring, and seed production.

PNW CONSERVATION FARMING HANDBOOK IN PRESS

Roger Veseth
Extension Conservation Tillage Specialist WSU/UI

The increased use and success of conservation farming systems throughout the Northwest in recent years is largely due to the adoption of new crop management technology. An increasing number of producers are realizing the importance of keeping up to date on new research technology in order to develop and maintain successful conservation farming systems. An important reference guide on this new technology will be a new Pacific Northwest Extension publication entitled the "*PNW Conservation Farming Handbook*". It is currently in press and will hopefully be available near the end of the summer. The intended audience is Northwest producers and all who assist producers with products, services and technology for crop production and land management.

The *Handbook* is an in-depth compilation of new research developments in conservation farming management technology in Washington, Oregon and Idaho. The purpose of the *Handbook* is to consolidate an extensive amount of existing information on conservation farming into an organized resource guide for increased information accessiblity. All of the *Handbook* publications have been completed since 1984. They are written from the perspective of how the new research developments can fit into a producer's management system.

Handbook Format

The *Handbook* is divided into 10 subject area chapters which best summarize the research technology available. Chapter titles are as follows:

1) Soil Erosion Impacts on Productivity
2) Conservation Farming Systems and Equipment
3) Residue Management
4) Plant Disease Control Strategies
5) Weed Control Strategies
6) Fertility Management and Fertilizer Application
7) Plant Development and Ground Cover Guides
8) Variety Development and Alternate Crops
9) Erosion Control on Irrigated Cropland
10) Economics and Application of Conservation Farming Systems

The *Handbook* currently includes more than 110 articles and publications. Once published, the Handbook will be kept current through a new *PNW Conservation Farming Handbook Series* and other PNW Extension publications. Consequently, the *Handbook* will also serve as a mechanism for distributing new developments in management technology in the future.

Technology Background

STEEP Research

Much of the latest conservation farming technology in the Northwest has been developed through a comprehensive research program entitled STEEP (Solutions to Environmental and Economic Problems). This program was initiated in 1975 to develop new management technology for more efficient crop production while protecting soil and water resources.

More than 100 scientists from the land-grant Universities and the USDA Agricultural Research Service in Idaho, Oregon and Washington have been involved in STEEP projects. Most projects are cooperative efforts between scientists from different disciplines, and many are interstate. The research has involved more than 12 disciplines including: plant pathology, weed science, soil fertility, agricultural engineering, plant breeding, soil physics, agricultural economics, soil microbiology, entomology, hydrology, meteorology and plant physiology.

The innovators of STEEP were the producer organizations in the Pacific Northwest. They arranged the initial discussions and have supported supplemental congressional funding for the program each year through USDA. The funds provide operational monies for research projects (not scientists salaries), so they augment University research budgets. STEEP funding has also provided the opportunity for long-term studies, rather than the usual 1-2 year grant programs more commonly available.

STEEP Extension

Keeping up to date on research conducted through a program such as STEEP has been very difficult because of the magnitude and complexity of the research effort. STEEP is solely a research program with no funding for companion extension-education component. In spite of efforts by existing Extension, SCS and research personnel in the first seven years of STEEP, information transfer was often very limited or at least there was a long time-lag between the research development and availability of that technology to producers.

Again at the request of Northwest producers, a STEEP Extension program was initiated in 1982 to speed the transfer of new conservation farming technology from the researcher to Northwest producers, and the Ag-support industry and agencies. Most of the funding for STEEP Extension has been provided primarily by Cooperative Extension and Wheat Commissions in the three states.

The program consists primarily of two Extension Specialists who concentrate on this technology transfer effort. They are Roger Veseth, Extension Conservation Tillage Specialist with Washington State University and University of Idaho, and Don Wysocki, OSU Extension Soil Scientist at Pendleton. Veseth and Wysocki are coauthors of the new *PNW Conservation Farming Handbook*. The Specialists are working in cooperation with the STEEP researchers, other Extension Specialists and Agents, Conservation

Districts, USDA-SCS staff, producer organizations, the Ag service industry and other groups.

A variety of technology transfer methods are utilized in the STEEP Extension effort, including: quarterly issues of the STEEP Extension Conservation Farming Update; farm magazine/newspaper articles; Pacific Northwest Extension publications, such as the *PNW Conservation Farming Handbook*; conferences and workshops; meeting presentations; demonstrations and field tours; and audio-visuals. For more information on the *Handbook* and other STEEP Extension efforts, contact Veseth (208) 885-6386 or Wysocki (503) 276-5721. Their mailing address are: Roger Veseth - Plant, Soil and Entomological Sciences Dept., University of Idaho, Moscow, ID 83843-4196; and Don Wysocki - Columbia Basin Agricultural Research Center, Box 370, Pendleton, OR 97801.

CONTROL OF STRIPE RUST, LEAF RUST AND STEM RUST

Roland F. Line
USDA, Plant Pathology

General Characteristics. Three rusts (stripe rust, leaf rust, and stem rust) occur on wheat in the Pacific Northwest. Stripe rust appears as golden-yellow, long, narrow stripes on the leaf surface and glumes; leaf rust appears as small, red pustules on the leaf surface and leaf sheath; and stem rust appears on the stems and as larger, red-brown, diamond-shaped pustules on the leaf surface. Stripe rust and stem rust can also occur on the heads. Stripe rust and leaf rust overwinter on wheat and rapidly increase during the spring. Stripe rust develops during the cool temperatures of early spring. Leaf rust develops at warmer temperatures later in the spring. Stem rust occurs on both wheat and barley. The stem rust pathogen does not usually survive on living wheat plants during the winter. It survives as dormant spores on straw and depends upon the common barberry for completion of its life cycle. In the spring, the dormant spores germinate and produce another type of spore that infects barberry leaves but not wheat. Spores produced on the barberry are the source of inoculum for the wheat in the spring. Therefore, elimination of the barberry would eliminate or reduce stem rust.

Historical Importance. In the late 1950's and early 1960's stripe rust caused losses in excess of 50 percent. Since then, destructive epidemics of stripe rust have occurred in fields of susceptible varieties in three out of four years. Stripe rust reduced yields in the Pacific Northwest by more than 20 percent in 1981 and more than 15 percent in 1983 and 1984. Without development of resistant varieties and emergency registration of a fungicide (Bayleton) for rust control, losses caused by stripe rust in Washington would have exceeded 50 percent in 1981 and 30 percent in 1983 and 1984.

As we develop varieties with better stripe rust resistance, leaf rust becomes more important because tissue not damaged by stripe rust is damaged by the later developing leaf rust. Consequently, leaf rust has become increasingly more important since 1962. In 1974, losses caused by leaf rust in Twin spring wheat exceeded 50 percent. Within the last 15 years, leaf rust has caused widespread, severe losses in every year except 1977, 1979, 1982, 1985, 1986, and 1988. In irrigated fields, leaf rust causes losses almost every year and those losses have sometimes exceeded 60 percent. In 1980 to 1984, stem rust significantly damaged wheat and barley in eastern Washington and Oregon and northern Idaho, especially in late maturing fields.

Monitoring Rust. Thirty-nine races of Puccinia striiformis, the pathogen that causes stripe rust, have been identified. In 1988, races virulent on Fielder, Moro, Jacmar, Barbee, Faro, Weston, Tyee, Hatton, Tres, and seedlings of Stephens, Hill 81, and Daws were prevalent, and severe rust was observed in Owens spring wheat in central Washington for the first time. Most winter wheat varieties currently grown in the region are very susceptible to leaf rust. Since the current races can attack most varieties, there is no major selective pressure for new races of leaf rust. Consequently, no significant new races of Puccinia recondita, the pathogen causing leaf rust, were detected in 1988. We have more races of stem rust in the Pacific Northwest than in all of the other regions of the United States, and races of Puccinia graminis, the pathogen causing stem rust, are uniquely different from races in the other regions. The

Effect of Weather. The rusts are obligate parasites and must have a living host to grow on. The continual presence of living wheat plants throughout the year provides a host for the rust and adequate inoculum for initiation of new stripe rust and leaf rust epidemics, and many current varieties are susceptible to races of rust that occur in the region. Therefore, the factor that is most limiting for rust development is the weather. When used in combination with monitoring data, a model for predicting stripe rust, based on winter and spring temperatures has proved to be reliable since 1979, and when used with precipitation data has enabled prediction of leaf rust and stem rust. In 1988, stripe rust, leaf rust, and stem rust developed late in the growing season because of unusually dry conditions in the fall, winter, and early spring and cold winter temperatures. Consequently, damage from the rusts was minimal, except for a few fields. The weather from fall to the end of January 1989 was very favorable for rust development. However, unusually cold weather in February reduced the amount of rust that over wintered. Thus stripe rust development should be later than usual. However, the extensive acreage of spring wheat could be severely damaged, if precipitation is frequent and temperatures are cool in June and July.

Resistance. High-temperature, adult-plant (HTAP) resistance to stripe rust, which has now been incorporated into all major soft white winter wheats and most spring wheats (see Table 1), has continued to be durable against all races in the Pacific Northwest; whereas, the high resistance expressed in both seedling and adult plant stages at all temperatures has been effective for three years or less. Information on the characteristics and inheritance of HTAP resistance in Gaines, Nugaines, Luke, Stephens and Daws (five varieties with different levels of HTAP resistance and different genes for resistance) has been obtained based on analysis of advanced progeny from crosses of the varieties and crosses with a susceptible club wheat. Evaluation of advanced generations from crosses involving HTAP resistant Gaines, Nugaines, Luke, Daws, and Stephens at three locations in Washington showed that the highest resistance could be more clearly identified at Mt. Vernon than at the other sites, yield losses were most highly correlated with stripe rust severity at heading to milk stages, and additional resistance can be detected in the advanced families. Incorporation of HTAP resistance into club wheats has not been as successful because of the nature of the club wheats, their narrow genetic base, and the quality requirements desired. The HTAP resistance that was transferred into the club wheat may be useful in developing club wheats with better stripe rust resistance. Also, new information on the inheritance of race-specific resistance has been obtained and should be useful in developing new disease control programs, identifying races, and understanding how resistance works.

Based on studies of the inheritance of slow rusting resistance to leaf rust, Borah, Wampum, and Wared each contain several genes for resistance to leaf rust, and the genes in each cultivar are different from those in the other cultivars. These genes should be useful in developing more durable leaf rust resistant wheats.

We are currently evaluating the national germplasm collection for HTAP resistance in the field at Mt. Vernon and Pullman, WA and for specific resistance to the four most virulent stripe rust races in the greenhouse. The four races include all of the identified virulences in North America. As of this data, more than 28,000 germplasm entries have been evaluated in the field and half of those have been evaluated for resistance to each of the four races. In addition, we are evaluating commercial varieties, advanced breeding lines from breeders in the Pacific Northwest, and differential cultivars for resistance to stripe rust and leaf rust The information on resistance of germplasm and advanced lines should provide breeders with new sources of resistance and should lead to a better understanding of how to use resistance and an improvement in the resistance of wheat varieties in the future.

Use of Fungicides. As part of an integrated disease control program we have continued to study the use of fungicides for control of the diseases. Foliar applications of Bayleton, Tilt, Folicur, and Spotless controlled stripe rust, leaf rust, stem rust, and powdery mildew, especially when applied at jointing to boot stages of growth, and effectively prevented wheat losses in the Pacific Northwest. Baytan, Folicur, and Spotless applied as seed treatments show possibilities for control of early rust development, if they are managed to prevent the delay in emergence that can sometimes occur. Bayleton has been used since 1981 to control stripe rust and leaf rust when existing varieties become susceptible to new races and in combination with various types of resistance, and Tilt was registered for rust control in 1988. Guidelines for the use of the chemical have been developed based on type of rust, type of resistance, intensity of rust, stage of growth, potential yield, and economic return.

Table 1. Seedling and adult plant resistance to stripe rust of cultivars grown in the Northwestern United States[a]

Cultivar	Stripe Rust Seedling	Stripe Rust Adult	Cultivar	Stripe Rust Seedling	Stripe Rust Adult
Soft White Winter Wheat			Hard Red Winter Wheat		
Stephens	S	R	Batum	S	R
Luke	S	R	Wanser	S	MR-MS
Lewjain	S	R	McCall	S	MS
Dusty	S	R	Centurk	S	MS-S
Daws	S	R-MR	Hatton	S	MS-S
Hill 81	S	R-MR	Weston	S	S
Malcolm	S	R-MR			
Hyslop	S	R-MR	Soft White Spring Wheat		
McDermid	S	MR-MS			
Nugaines	S	MR-MS	Twin	R	R
Gaines	S	MR-MS	Dirkwin	R	R
Walladay	S	MS-S	Penewawa	S	R-MR
Yamhill	S	S	Edwall	S	R-MR
			Waverly	S	R-MR
Club Wheat			World Seeds 1	S	R-MR
			Urquie	S	MR-MS
Crew	R+S	R+S	Walladay	S	MS-S
Tres	S	MS	Fielder	S	MR-MS
Moro	S	S	Fieldwin	S	S
Jacmar	S	S	Owens	S	S
Barbee	S	S			
Paha	S	S			
Tyee	S	S			

[a] R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible, and R+S = resistant plants and susceptible plants (multiline). High-temperature, adult-plant resistance is expressed as a range, except for highly resistant cultivars. Those cultivars currently susceptible in both the seedling and adult stage are resistant to older races in both the seedling and adult stage.

Table 2. Seedling and adult plant resistance to stripe rust of cultivars grown in the Northwestern United States[a]

Cultivar	Stripe Rust Seedling	Stripe Rust Adult	Cultivar	Stripe Rust Seedling	Stripe Rust Adult
Soft White Winter Wheat			**Hard Red Winter Wheat**		
Stephens	S	R	Batum	S	R
Luke	S	R	Wanser	S	MR-MS
Lewjain	S	R	McCall	S	MS
Dusty	S	R	Centurk	S	MS-S
Daws	S	R-MR	Hatton	S	MS-S
Hill 81	S	R-MR	Weston	S	S
Malcolm	S	R-MR			
Hyslop	S	R-MR	**Soft White Spring Wheat**		
McDermid	S	MR-MS			
Nugaines	S	MR-MS	Twin	R	R
Gaines	S	MR-MS	Dirkwin	R	R
Walladay	S	MS-S	Penewawa	S	R-MR
Yamhill	S	S	Edwall	S	R-MR
			Waverly	S	R-MR
Club Wheat			World Seeds 1	S	R-MR
			Urquie	S	MR-MS
Crew	R+S	R+S	Walladay	S	MS-S
Tres	S	MS	Fielder	S	MR-MS
Moro	S	S	Fieldwin	S	S
Jacmar	S	S	Owens	S	S
Barbee	S	S			
Paha	S	S			
Tyee	S	S			

[a] R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible, and R+S = resistant plants and susceptible plants (multiline). High-temperature, adult-plant resistance is expressed as a range, except for highly resistant cultivars. Those cultivars currently susceptible in both the seedling and adult stage are resistant to older races in both the seedling and adult stage.

STRAWBREAKER FOOT ROT AND CEPHALOSPORIUM STRIPE

Timothy Murray, Cheryl Campbell Walter, and Larry Specht

Strawbreaker foot rot (eyespot) is one of the most important and chronic diseases of winter wheat in eastern Washington. Cephalosporium stripe (fungus stripe) is another important disease that can be devastating, but epidemics are more sporadic in occurrence than foot rot. Both diseases are important on wheat seeded early on summer fallow, especially in areas with more than 16" annual rainfall, and where crop rotations are short. Early seeding is favorable to both diseases, but for different reasons. As plants become older and larger, they become more susceptible to infection by the fungus causing foot rot, *Pseudocercosporella herpotrichoides*, and they also provide larger targets for the spores of this fungus that are splashed around by rain. With cephalosporium stripe, root wounding is thought to be the primary mode of entry of the fungus, *Cephalosporium gramineum*, and the larger plants that result from early seeding have larger root systems and are more susceptible to winter root injury, and therefore infection. Yield losses of 50% can occur with strawbreaker and up to 100% when cephalosporium stripe is serious.

Unlike foot rot, cephalosporium stripe cannot be controlled with fungicides. The best control for this disease is crop rotations and host resistance. Some problems encountered in screening for resistance to cephalosporium stripe have been the lack of uniformity in disease development and the lower levels of resistance available to this pathogen. One of our goals has been to develop methods of inoculating plots to induce more uniform disease development and thereby facilitate screening. One factor that we are investigating is the effect of increasing soil acidity (decreasing soil pH) on cephalosporium stripe. Tests are now being conducted in both the greenhouse and field to determine if it we can use increased soil acidity to screen for resistance. Field experiments over the past three years have shown the potential for controlling cephalosporium stripe by liming. However, more work is needed to determine how liming affects disease development with different varieties. For example in our 1988 test, cephalosporium stripe was reduced by about 40% in both Daws and Stephens, but yield was increased significantly only in Stephens.

Other experiments are in progress to determine if the effect of liming on cephalosporium stripe is due to a change in soil pH or the addition of calcium to the soil. We are also looking at different methods of inoculation in the greenhouse to try and develop a greenhouse test for resistance that would be faster and more reliable than field screening methods. The long-term goal is to develop resistance varieties for control of cephalosporium stripe.

Currently, the most common control for strawbreaker foot rot is an application of a fungicide in the spring before jointing. One of the goals of this research program is to insure the continued availability of effective fungicides for control of strawbreaker foot rot. One potential problem for eastern Washington, and one that has occurred in Europe, is the development of resistance to Benlate, Mertect, or Topsin-M in the fungus that causes foot rot. Several new fungicides are being tested for use in combination with the current commercial fungicides. One of the promising experimental fungicides that we tested for the past three years, Prochloraz, was dropped by the company and will no longer be considered. However, we have had very good results in the past two years with DPX H6573 and Tilt, which received registration for use as a combination treatment for foot rot control this past year. Last year under severe foot rot conditions, both of these fungicides provided good disease control and significant yield increases. This year we are testing several new experimental fungicides in the foliar fungicide trial. In addition, we are conducting an extensive survey of winter wheat this year for resistance in the pathogen to the currently-used fungicides. This information is vital for determining future fungicide use and the role of combination fungicide treatments.

Resistant varieties offer the best long-term solution for controlling strawbreaker foot rot, because they are the cheapest and most reliable control measure, and because resistance appears to be stable, unlike other types of disease resistance. The recent release of the foot rot resistant varieties Hyak and Madsen, are milestones in research progress to control foot rot through genetic resistance. Incorporating resistance into commercial varieties has been difficult in part because the mechanisms and genetics of resistance are not well-understood. We have been studying resistance to try and understand what makes a plant resistant and how resistance is controlled genetically. Last year we reported on the results of genetic studies on resistance in seedlings. This year our emphasis is on the genetics of resistance in adult plants in the field to back-up the results from the lab and greenhouse. We have over 600 F_6 progeny lines, resulting from crosses between resistant and susceptible parents, planted in two-row plots. One-row of each plot is inoculated so we can evaluate disease resistance and yield loss. From this we hope to be able to estimate the levels of resistance necessary for economic control of foot rot.

BIOTECHNOLOGY MOVES FROM THE LABORATORY TO THE FIELD ON WHEAT

R. James Cook, David M. Weller and Linda S. Thomashow

On October 6, 1988, the USDA-ARS in cooperation with Washington State University and the Monsanto Company of St. Louis put out a field experiment with a genetically engineered strain of bacteria introduced into soil on wheat. The engineered strain is being tested along with its nonengineered (natural) parent for ability to control take-all, a root disease of wheat that affects an estimated 625,000 acres of wheat in the three Pacific Northwest states. The engineered strain is identical to its natural parental strain except for two genes from another bacterium that permit us to distinguish it from the tens of thousands of other bacteria that look just like it.

Our current research on biological control of take-all with bacteria grew out of experiments started at Pullman 22 years ago. The natural (parental) strain was first discovered in 1979 and has been field-tested in Washington state since 1980. Nevertheless, months of planning went into this particular field release, which was made on winter wheat on the Spillman Agronomy Farm. All necessary local, state, and federal approvals were granted in advance of sowing, including from WSU's Biosafety Committee, Washington State's Department of Agriculture in Olympia, the USDA's Animal and Plant Health Inspection Service (APHIS) and the U.S. Environmental Protection Agency (EPA).

The particular strain of bacteria engineered to contain "foreign genes" was obtained originally from a root of wheat growing in soil from a plot at Lind where wheat had been grown continuously and under irrigation since 1968. This strain was one of several isolated from wheat roots and suspected to play a role in the natural biological control of take-all with wheat monoculture. The two foreign genes engineered into it are from a common strain of bacteria that lives in the gut of humans. The usual function of these genes is to permit the bacteria to produce enzymes needed to grow on lactose (milk sugar). In our usage, one of these enzymes combined with tiny amounts of a special chemical dye causes the bacterial colonies to turn blue when cultured in the laboratory.

This marker system allows us to track the bacteria from the seed, where it is introduced, onto the roots where it is needed to protect against take-all. We can also now learn more about carry-over of this beneficial strain once the wheat is harvested. The marker system allows us to measure as little as one individual bacterial cell in one gram of soil.

All common wheats, so far as can be determined, are more or less equally susceptible to take-all. It does not seem possible, therefore, to control this disease by breeding new wheats, at least not with conventional plant breeding. However, these beneficial bacteria somehow team up with the roots of wheat to provide the equivalent of "resistance"--not perfect but a great advance over the situation without these bacteria. The beneficial bacteria have their own genes for production of natural substances inhibitory to take-all.

This is a new approach to genetic control of disease, where the necessary genes for plant defense are carried by and expressed in microbes delivered with (on) the seed rather than in the seed itself. Our research covers many facets, including how the bacteria inhibit the take-all fungus, the basis for the root-bacteria association, and formulations for delivery of these beneficial microorganisms. This is a long-term project and a joint venture between industry, the USDA, and Washington State University.

TAKE-ALL

R. J. Cook and D. M. Weller

Take-all is a problem in areas receiving at least 22-24 inches of water as precipitation or (precipitation plus irrigation) annually. With no-till, on the other hand, the disease can be severe in areas with 18-22 inches of rainfall annually, but is rare regardless of tillage system in the intermediate and low rainfall areas of eastern Washington. A survey in 1983 indicated that about 625,000 acres of wheat were affected by take-all in the three northwest states that year, about half in Washington. Take-all is probably the most important production constraint for irrigated wheat in central Washington. Symptoms include blackened roots, and the lower 1-2 inches of the stems of severely diseased adult plants also may be blackened by the fungus. Plants infected early may be stunted and appear nutrient deficient, because the damaged roots are inefficient in uptake of nutrients. When the fungus rots the lower stem tissues, plants die from lack of water to the tops and develop "white heads." The fungus lives in the crop residue and is especially successful when crowns of infected plants are left undisturbed (as with no-till); the fungus can then grow from this large food base directly into the plants of the succeeding crop.

The best control for take-all is to not grow wheat or barley in the same field more than once every two years where tillage is used and possibly no more often than every third year if no-till is used. Potatoes, alfalfa, corn, beans, peas, and lentils are all nonhost crops and break the take-all cycle. If wheat must be grown more frequently, then irrigation water supplied in large but infrequent applications e.g., 3-4 inches every 7-10 days (as is possible with rill or solid-set systems) will help keep the disease in check. The disease is very sensitive to soil drying, whereas pivot irrigation is especially favorable to the fungus. Thorough tillage where wheat follows wheat or barley helps control the disease by accelerating the death rate of the fungus, but should be considered as an option for take-all control only if a rotation is not followed. In fact, results of experimental trials make it abundantly clear that take-all control presently is not possible in consecutive crops of irrigated wheat without some tillage.

A major objective of our research is to control take-all without crop rotation and with less tillage. Good phosphorus fertility can give some control. The disease eventually declines with prolonged monoculture of wheat (take-all decline), because of a natural biological control, but this process is effective only if some tillage is used. Moreover, we have now shown in a long-term (20-year) trial with continuous irrigated wheat at Lind that as take-all declined, Rhizoctonia root rot increased.

We are attempting to develop a biological control whereby antagonistic root-colonizing bacteria (obtained from soils where take-all has declined) are applied as a living seed treatment to protect the roots. An average yield increase of 10-15 percent has been obtained in 10 trials carried out since 1982 in commercial fields where take-all was the main yield-limiting factor. There is commercial interest in development of a biocontrol product with one or more of our bacterial strains.

RHIZOCTONIA ROOT ROT

R. J. Cook and D. M. Weller

Rhizoctonia root rot was found in the U.S. for the first time in 1984, in six different fields of wheat or barley in the Pacific Northwest. Since then, this disease has been found in many fields in eastern Washington, and has occurred in devastating amounts in some cases. At least two species of Rhizoctonia are responsible for the disease; R. solani when soils are cool (40-50° F), and R. oryzae when soils are warm (60-80° F). Winter and spring cereals, peas, lentils and rape all are susceptible, but spring barley is affected more severely than any other crop grown in the Inland Northwest. Severe Rhizoctonia root rot depends on the amount of infested root tissue carried over from the previous crop. The greater amount of this disease on barley may reflect the fact that barley follows wheat. Grain crops with their dense fibrous root systems leave more residual infested roots than do peas or lentils with there more sparse root systems. Cheatgrass is also very susceptible and can serve as a reservoir of inoculum of the fungus.

Rhizoctonia root rot is favored by continuous cropping of winter and spring cereals and by reduced or no tillage. A full year of clean fallow (no weeds or volunteer), either conventional or chem fallow, helps greatly to lower the amount of fungus to safer (less damaging) populations. No-till is relatively risk-free if following a clean 1-year break of chem fallow. Alternatively, the disease can be controlled to a significant extent (but not completely) in continuous cereals (wheat or barley) if some tillage is used. We now have evidence that even some form of soil disturbance within each seed row at the time of sowing into otherwise undisturbed soil can provide some relief from this disease. The highest risk of disease occurs with continuous no-till wheat or barley. The lowest risk is with winter or spring cereals grown after a full year of fallow with conventional tillage.

Significant disease control can be achieved with spring wheat or barley seeded into stubble if the weeds and volunteer are killed well in advance of planting. By this approach, the potential host plants of Rhizoctonia do not become large reservoirs of the fungus. If glyphosate is used, and the plan is to seed spring grains into stubble, the chemical should be applied in the fall, or at least 2-3 weeks before planting in the spring (if possible) to allow time for the fungus population to peak and then subside on the roots of the dying grass hosts and volunteers. The greatest amount of this disease in continuous cereals with minimum or no tillage has occurred where glyphasate was applied only a few (e.g. 3) days before sowing into lush (but dying) cover of cheatgrass and volunteer wheat.

Our field research on this disease is carried out on spring barley at Lind on the station and on winter wheat in a commercial field near Fairfield, Washington. The work is aimed at understanding the ecology of the disease and at finding an effective management practices and seed-treatment chemicals.

PYTHIUM ROOT ROT

R. J. Cook

Pythium root rot occurs on wheat and barley throughout the Inland Northwest but limits yields mainly or exclusively in areas with 16-17 inches of precipitation or more annually and in acid silt and clay loam soils typical of far-eastern Washington and adjacent northern Idaho. Several species of this fungus are involved. The disease begins with a generally nonlethal infection of germinating seeds during the first 1-2 days after planting in moist soil. As the young plants develop, *Pythium* destroys root tips, root hairs, and branch roots on wheat and barley. A typical effect of *Pythium* is distinctly smaller plants adjacent to larger more normal plants. The disease also results in fewer tillers, smaller heads, and nutrient-deficiency systems because of the lack of root hairs and branch roots needed to absorb nutrients.

Yields of wheat in the high-production, annually cropped areas of eastern Washington and northern Idaho would be 10-20 and sometimes 30-40 bu/A greater (depending on the planting date, tillage, and rotation) with the same water and current rates of fertilizer if *Pythium* could be controlled completely. The disease occurs to a remarkably uniform degree in wheat and barley fields of this region. *Pythium* uses nutrients from straw and chaff as a food source and is also favored as a pathogen by the cool, wet soil conditions typical of late sowings and soil with surface residues. The fungus is also more damaging on old (3-5 yr) than current-year seed.

Work on *Pythium* control involves a search for a biological or chemical seed treatment. Apron is the only effective seed-treatment chemical found to date, but we now have evidence that where Rhizoctonia and Pythium root rots occur as a mixture, control of only Pythium root rot with Apron can have a negative effect on the wheat, possibly by increasing Rhizoctonia root rot.

The only field treatment effective at present against root infections is fumigation of the soil with chloropicrin or Telone C17, but the effective rates are uneconomical. In contrast, low rates of metham sodium (e.g. 4-5 gal/A) might be economical but in our trials they have been ineffective. Our current field studies on Pythium root rot are carried out as part of the IPM study near Albion, on the Palouse Conservation Field Station, on the WSU Plant Pathology Farm in Pullman, and in commercial fields near Fairfield, WA, in cooperation with Mr. Chas. Keno.

The best control at present for Pythium root rot on winter wheat is to seed relatively early, e.g. mid to late September in areas with 18-20 inches of precipitation annually. Seeding this early is relatively safe if the field is in a three-year rotation but is risky if the field is in a two-year rotation (because of Cephalosporium stripe). If wheat must be sown late, e.g. early- to mid-October in areas with 18-20 inches of precipitation annually, it is best to use fairly new or current-year seed.

CONTROL OF DOWNY BROME AND JOINTED GOATGRASS USING SOIL BACTERIA

A.C. Kennedy, F.L. Young, A.G. Ogg, Jr.

Winter annual grass weeds are the major weed problem of winter wheat producers. In the western United States jointed goatgrass infests more than 2.5 million acres of wheat and in Washington more than 0.5 million acres are infested. Downy brome and other Bromus sp. infest 14 million acres in the western United States and approximately 0.75 million acres in Washington. Each of these weed species reduces wheat yields 10 to 15%. Herbicide programs have been developed for the control of some of the major winter annual grass weeds, however for others no selective chemical control is available or costs are prohibitive. The best control is often achieved by planting continuous spring crops for 2 or more years; however, this practice may not be economically feasible.

Biological control offers an effective alternative method to suppress weeds. Soil bacteria that inhibit root growth of various grass weed species but do not negatively affect the crop have recently been isolated. These naturally-occurring soil bacteria suppress plant growth by the production of a compound which specifically inhibits downy brome or related plant species. The bacteria are excellent biological control agents because they are aggressive colonizers of the roots and residue and they function as a direct delivery system for the natural "herbicide" they produce. Most of the bacteria studied inhibited root growth, although in some cases weed seed germination also was reduced. These inhibitory bacteria cause the greatest reduction in downy brome growth at low temperatures. They are most prevalent in the soil in late fall and early spring. Application of these bacteria and the resultant suppression of the root growth of downy brome may allow the crop to out-compete the weed.

Field studies were conducted in 1987-88 at four sites in eastern Washington to evaluate the effect of the inhibitory bacteria on the growth of downy brome. Weed-inhibitory bacteria were applied to wheat fields infested with natural populations of downy brome. Downy brome and winter wheat growth and development were measured throughout the growing season. Reduction in downy brome growth varied and was dependent upon the specific bacterial strain. One strain of inhibitory bacteria reduced plant populations and above-ground growth of downy brome 31 and 53%, respectively. In the same experiments, seed production of downy brome was reduced 64%. Winter wheat yields were increased by 35% with the application of the bacteria and subsequent suppression of downy brome growth. This increase in yield is similar to the yield increase expected from the elimination of moderate infestation of downy brome. Thus far, field studies and laboratory studies have indicated that inhibitory bacteria can suppress the growth of weeds, resulting in substantial increases in winter wheat yields.

Current biological control research includes isolation of new strains of bacteria and field evaluations of these bacteria for the suppression of downy brome and goatgrass. Field experiments are being conducted at Pullman and Lind, WA to evaluate the concentration and time of application of the inhibitory bacteria as prospective weed control methods. The combination of bacteria plus herbicides is also being evaluated. At Lind, fall applications of inhibitory bacteria reduced downy brome populations up to 40%. The bacteria did not reduce winter wheat or jointed goatgrass populations at either location. When herbicides did not control downy brome 100%, the addition of bacteria further reduced the weed populations.

SOIL FERTILITY MANAGEMENT FOR CROP PRODUCTION IN EASTERN WASHINGTON

F. E. Koehler and E. T. Field

Field experiments concerning soil fertility management for crop production are widely distributed throughout the wheat producing area of eastern Washington. A number of these involve a no-till management system. The use of spring top dressing with nitrogen for winter wheat has been studied with rates and sources of nitrogen with and without sulfur being used. Other experiments include further studies on nitrogen rates and sources, placement and rate of phosphorus fertilizer, use of sulfur, rates and sources of nitrogen and sulfur with and without phosphorus and zinc for spring grain, sources and methods of application of various kinds of fertilizers including micronutrients with a no-till system, fertility requirements for hard red wheat production, phosphorus distribution in soils, and fertility requirements of peas, winter peas and lentils. In recent years there have been less responses than expected to spring top dressing of winter wheat with nitrogen. Where there have been responses, all sources of nitrogen were equally effective.

No-Till Management

In general, where moisture is limiting, no-till gives wheat yields which are as good or better than those obtained with conventional tillage. In the higher rainfall areas where moisture is not as limiting for production, management problems other than fertility in the no-till system have sometimes resulted in yields less than those obtained with conventional tillage systems. With a no-till system for spring wheat, placing all fertilizer below the seed normally produces considerably higher yields than does broadcasting the nitrogen and sulfur. In 1982 yields of no-till spring wheat were 47% lower where the nitrogen and sulfur were surface applied than where it was placed below the seed; in 1983, 49% lower; and in 1984, when there was more spring and early summer rainfall than normal, only 5% lower. When fall rains come too late to allow for germination and subsequent killing of weeds prior to seeding winter wheat, it is very difficult to control grassy weeds in a no-till system.

At one location near Davenport no-till has been compared with conventional tillage for 10 years. The average yields of winter wheat have been about the same for the two systems. For spring wheat the conventional tillage has averaged about 5 bu/a more than the no-till system.

In a series of maximum yield experiments over four years, the effect of phosphorus fertilizer on winter wheat yields has been studied. Maximum yields exceeded 100 bu/a at 6 of the 17 sites. At two of these high yielding sites where the soil test values for phosphorus were low, there were increases of 8 and 10 bu/a from the addition of phosphorus fertilizer. At the other sites there was little response to phosphorus. These data indicate that eastern Washington growers are doing a good job of maintaining adequate levels of phosphorus in their soil.

Spring barley gave a yield response to shanked-in phosphorus in one of four locations, as a WSU soil test had predicted. There was no response to zinc at any location. All zinc soil test levels were at 0.5 parts per million or higher, which is considered adequate for small grains.

Peas and Lentils

Field correlation fertility trials with dry peas and lentils to identify any needed changes in fertilizer recommendations were started in 1986. No changes from present recommendations were detected in three years of trials. Molybdenum as a seed treatment is generally recommended for each crop on Palouse and Athena type soils. Sulfur is also recommended except when it was applied to the previous crop in the rotation.

Fertility and stubble management effects on cold stress tolerance of Austrian winter peas is being evaluated at 16" and 22" rainfall sites. Standing stubble is being compared to stubble removed and conventionally tilled management to examine the effects on soil, temperatures and winter survivability. Phosphorus and potassium requirements for maximum survivability are also being evaluated.

Soil Acidity

Soils of this region are becoming more acid (soil pH is decreasing) because of (1) leaching of bases (calcium, magnesium and potassium) from the soil; (2) removal of these bases in crops, and (3) the use of ammonium-type fertilizers. The third factor has by far the greatest influence, and in about 35 years of nitrogen fertilizer use here the soil pH have dropped about 1 unit. In the natural soil development process, the greater the rainfall the lower the soil pH. Therefore, any problems associated with soil acidity in eastern Washington will be greatest near the Idaho border and will decrease as one goes west to drier climates.

Crops vary greatly in response to soil acidity, with legumes requiring higher soil pHs than grain crops. There is also considerable variability among varieties of the same crop in sensitivity to soil acidity.

As soils become more acid the amount of soluble aluminum increases, and aluminum is toxic to plants. Manganese may also become toxic in acid soils. Molybdenum, a plant micronutrient often deficient for legumes in this area, becomes less available as soil acidity increases. There are many soil pH-plant disease interactions.

The nature of plant reactions and the remedies required to solve soil acidity problems may be different in this area from those in other areas since here subsoils normally have a higher soil pH than topsoils and the acidification from the use of ammonia-type fertilizers usually affects only the tilled layer of soil. In a study on Spillman Farm, there has not been much difference in yields of wheat and peas on plots with soil pHs of approximately 5, 6, and 7.

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