WSU FIELD DAYS

June 21, 1984
Dry Land Research Unit, Lind

June 28, 1984
Palouse Conservation Station
Field Day, Pullman

July 5, 1984
Spillman Farm, Pullman

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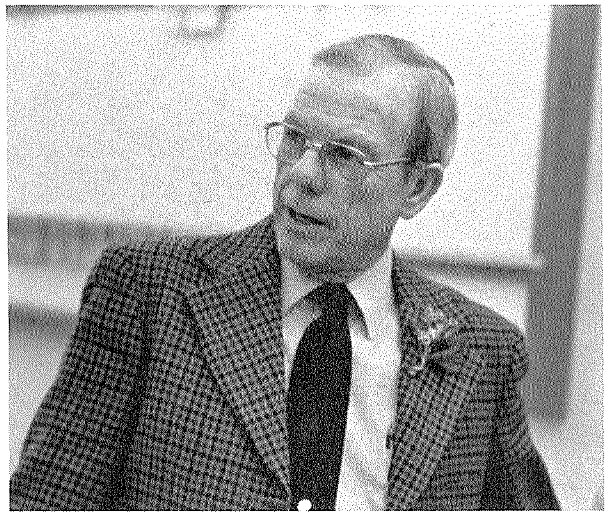
DEDICATION



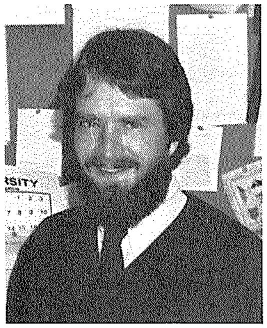
R. L. Hausenbuiller Retires

Dr. Robert L. Hausenbuiller, Professor of Soils at Washington State University, retired in the spring of 1983. Bob has been associated with WSU since 1941 when he began his Master's program. He received both his MS and PhD degrees from WSU. In 1956, he became an Assistant Professor at the Washington State University Intercollege Exchange Program in Lyallpur, West Pakistan.

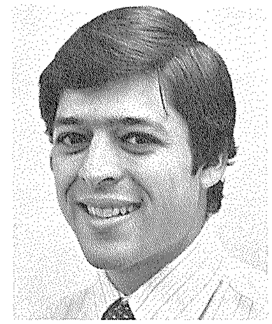
At WSU, he has taught Soils 201 since 1960 and Soils 301 since 1968. In 1964, he was the first recipient of the R. M. Wade Outstanding Teacher in Agriculture Award. His comprehensive text, *Soil Science*, was published in 1968. His particular area of expertise has been soil fertility.

In March of this year, Bob and his wife June went to Indonesia for 3 months where he is working with a USAID/Washington State University project. Upon their return, they will continue to reside in Pullman.

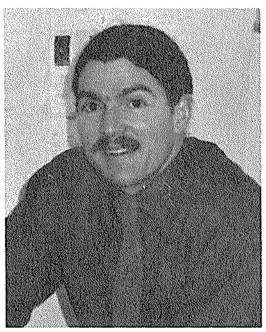
NEW FACULTY



Dr. James B. Harsh joined WSU in the fall of 1983 on a temporary appointment replacing Dr. Brian McNeal. In February he became a permanent member of the staff. Dr. Harsh earned a Ph.D. in Soil Chemistry from the University of California at Berkeley. His doctoral thesis was "The Nature and Sorption Properties of Hydroxy-Aluminum Clay." He teaches Soil Chemistry and Advanced Soil Chemistry.

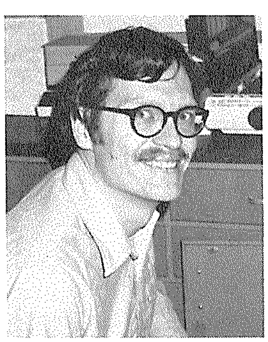


Dr. David J. Mulla came to WSU in the fall to fill the position in Soil Physics vacated by Dr. Walter H. Gardner. Dr. Mulla received his Ph.D. in 1983 from Purdue University. His current research includes the development of time domain reflectometry for measuring frost depth in cold region soils, computer modeling of water and sediment transport processed in porous media and the study of the mechanisms of solute and pollutant transport in soils and near plant roots.



Dr. John Reganold received his doctorate in 1980 from the University of California at Davis. He has worked for the Soil Conservation Service as a land reclamation specialist and as a private soils consultant. His work in reclaiming lands used for surface coal mining has taken him to Chile, Indonesia, and South Africa. His main research interests are prime farmland preservation and mined-land reclamation and he teaches the Soils 201 classes.

Dr. Thomas A Lumpkin, (WSU B.S. 1976), returned to Pullman to join the Agronomy staff. He completed his Ph.D. at the University of Hawaii in 1983. His research concentrated on the taxonomy, biology and agronomic use of azolla, particularly as a green manure crop for rice. Currently his research also includes studies of crop rotations with lupines, lentils and vetch. While doing research in China, he recognized a need for a Chinese-English glossary of agronomic terms, and he is supervising this compilation now.



Dr. Steve Spaeth recently was hired by the USDA-ARS to conduct research with peas and lentils. He is a 1982 graduate of New York State College of Agricultural Sciences (Cornell) in Ithaca, New York. His doctorate work was in legume genetics and physiology and post doctorate research at the University of Florida in Gainesville and Hokkaido University in Japan included soybean growth and development.

HISTORY OF 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 of information 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 $6000 to start the station and the land has been donated by the county. In the early 30's 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 over fifty 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 has 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 machine storage built shortly after the station was established. The old barn was dismantled in April 1973 and the residence in 1979. A small elevator 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. With the addition of a 12' x 60' trailer house, residence 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.

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. 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 67th field day. Visitors are welcome at any time. 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 1880's.

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 lower evaporation-transpiration rates during the months of maximum precipitation in both summerfallow and crop years.

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

	Temperature °F.		Precipitation		Precipitation
Month	Max.	Min.	1983	1984	63 yrs. av. (in)
January	34	22	1.09	.67	1.02
February	42	24	1.81	.82	.89
March	53	32	1.84	1.76	.76
April	63	35	.46	1.54	.66
May	72	42	.73		.78
June	83	45	.91		.85
July	90	52	.85		.25
August	90	50	.09		.33
September	79	45	.46		.56
October	65	38	.83		.88
November	47	29	2.67		1.21
December	37	26	1.62		1.30
			13.36		9.49

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, 1983 and 1984

Month	Monthly Avg. Temperature (F)		Precipitation				
	Max.	Min.	30-Yr. Avg.*	Monthly	Total Accum.	Deviation from Avg. Monthly	Deviation from Avg. Accum.
1983							
January	42.5	30.6	2.79	2.82	2.82	+0.03	+0.03
February	45.1	33.2	2.06	3.05	5.87	+0.99	+1.02
March	50.7	35.2	1.84	3.49	9.36	+1.65	+2.67
April	56.0	32.5	1.55	0.85	10.21	−0.70	+1.97
May	67.6	40.6	1.53	1.55	11.76	+0.02	+1.99
June	70.2	45.4	1.65	2.16	13.92	+0.51	+2.50
July	75.4	50.9	0.45	1.75	15.67	+1.30	+3.80
August	84.1	53.1	0.64	0.67	16.34	+0.03	+3.83
September	68.2	40.7	1.14	0.91	17.25	−0.23	+3.60
October	60.5	37.4	1.83	0.94	19.19	−0.89	+2.71
November	46.2	33.9	2.66	4.57	22.76	+1.91	+4.62
December	27.3	16.3	2.67	3.10	25.86	+0.43	+5.05
TOTAL	57.8	37.5	20.81	25.86	25.86		+5.05
1984							
January	37.7	26.2	2.79	1.94	1.94	−0.85	−0.85
February	41.6	29.0	2.06	1.74	3.68	−0.32	−1.17
March	48.4	34.3	1.84	3.34	7.02	+1.50	+0.33
TOTAL			6.69	7.02	7.02		+0.33
1984 CROP YEAR Sept. 1983 thru March 30, 1984			14.99		16.54		+1.55

*Thirty-year average for precipitation, 1941-1970

ADAPTED VARIETIES—WHEAT, OATS, BARLEY

AREA	WINTER WHEAT	SPRING WHEAT	OATS	SPRING BARLEY	WINTER BARLEY
EASTERN WASHINGTON 14 Inches or More Rainfall	Nugaines Daws Stephens Tyee Hill 81 Lewjain Crew	Urquie Dirkwin Waverly	Cayuse Appaloosa	Steptoe Advance—malting Belford—hay only Vanguard—malting barley Andre—malting	Kamiak Boyer
EASTERN WASHINGTON Less Than 14 Inches Rainfall	Wanser McCall Hatton Sprague Lewjain Moro Hatton Tyee Crew	Wampum Twin Urquie Waverly Dirkwin		Steptoe	Kamiak
CENTRAL WASHINGTON Under Irrigation	Daws Stephens Hill 81 Lewjain	Urquie Wampum Waverly Dirkwin	Cayuse Appaloosa	Andre Klages Steptoe Belford—hay only	Boyer Hesk
Snow Mold Areas	Sprague				

WHEAT, BARLEY, AND OATS

Kenneth J. Morrison
Washington State University

Winter Wheat

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 to 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.

The test weight is higher than Barbee, Tyee and Faro but it is lower than most common white wheat varieties.

The emergence of Crew is similar to Faro but less than Moro, but it is better than Tyee and Daws. The cold hardiness of Crew is similar to Faro, Moro and Elgin but it is inferior to Daws and Jacmar for regrowth after freezing.

Crew is similar to Faro in milling and baking quality. In bad rust years Crew mills better than most clubs because it has higher test weight.

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.

Nugaines

Nugaines is a soft white semidwarf winter wheat with excellent test weight, milling, and baking properties. The variety has a bearded, common-type head with white chaff.

Nugaines is not as winterhardy as Daws or the hard red winter wheat McCall or Wanser but is hardier than Luke and Paha.

Nugaines has good mature plant resistance to stripe rust but is susceptible to stripe rust in the seedling stage. It is also susceptible to leaf rust, dwarf bunt, snow mold, and *Cercosporella* foot rot.

Nugaines is resistant to most races of common bunt and has moderate resistance to flag smut and *Cephalosporium* stripe (fungus stripe). Nugaines was developed by USDA-ARS and Washington State University.

Daws

Daws is a soft white common semidwarf winter 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.

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.

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 winter hardy than Stephens but is not as winter hardy 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.

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.

Tyee

Tyee is a soft white club winter wheat with compact heads and awnless white chaff. It is a semi-dwarf wheat that is medium in maturity. The variety has high resistance to stripe rust that is different from the resistance in Moro, Barbee, and Faro.

The emergence is about the same as Paha. Emergence would be slower than Moro. The variety is moderately susceptible to flag smut. It has about the same common bunt or common smut resistance as Nugaines. It is susceptible to dwarf bunt. Tyee has the same susceptibility to leaf rust as Barbee, Faro, and Moro. The variety is highly susceptible to mildew. Tyee has about the same tolerance to strawbreaker foot rot as Barbee. It is more tolerant than Paha or Nugaines. Data is not available on *Cephalosporium* stripe (fungus stripe).

Tyee has high yielding ability, exceeding Paha, Moro, and Barbee and often better than Faro. It has test weight comparable to Moro and Barbee. It is 1 to 2 inches taller than Faro, 1 to 5 inches taller than Nugaines, and 5 inches shorter than Moro. Tyee has more lodging resistance than Paha and considerably more resistance than Moro.

The variety has about the same winterhardiness as Nugaines and, under some conditions, may prove to be better than Nugaines.

The quality of Tyee is similar to Moro but somewhat lower in quality than Paha. It may be superior to Faro for low ash content and increased cookie diameter. The variety was developed by wheat breeding and production of USDA-ARS and released jointly by the Washington, Oregon, and Idaho Agriculture Experiment Stations.

Moro

Moro is a soft winter club wheat with brown chaff. Its chief advantages are resistance to stripe rust and excellent emergence. It is susceptible to leaf rust. When stripe rust is severe, Moro produces much better yields than stripe rust susceptible varieties. Moro is resistant to most races of dwarf bunt and common bunt. Moro is moderately resistant to *Cephalosporium* stripe (fungus stripe).

Moro is a good pastry flour; however, it has a higher flour viscosity than other club varieties. Moro is a medium-tall club variety with white kernels. Moro does not have the high yield potential of other club varieties in the higher rainfall areas. In the lower rainfall areas of Washington, where it is difficult to obtain stands with other varieties, Moro will germinate and emerge much better than other varieties from deep seedlings in dry, dusty seedbeds. Moro was developed by Oregon State University.

Wanser and McCall

Wanser and McCall are hard red winter wheats developed for low rainfall areas of Washington. Both varieties yield well in areas that have less than 13 inches of annual rainfall. The two varieties can be distinguished by chaff color. Wanser has a brown-chaffed head and McCall has a white-chaffed head. Both have bearded, lax spikes.

Both varieties are resistant to common smut and most races of dwarf bunt. Wanser shows superiority over McCall in stripe rust tolerance, and winterhardiness is important for maximum production.

McCall is well-adapted to the northern section of the Big Bend area, including Douglas, Grant, and Lincoln Counties. McCall is superior to Wanser in both snow mold tolerance and emergence from deep seedings—two qualities important to production in that area. McCall recovers rapidly in the spring which is another advantage for the northern area.

McCall has good winterhardiness, but less than Wanser. Both Wanser and McCall are more winterhardy than Nugaines, Daws, or the club wheats. Wanser and McCall are shatter resistant.

Wanser mills better than McCall. McCall has slightly better bread-baking qualities than Wanser. Neither is suitable for production of soft white wheat products. Wanser and McCall were developed by USDA-ARS and Washington State University.

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.

Spring Wheat

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.

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 desirable straw height for non-irrigated 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 non-irrigated or irrigated land.

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.

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.

Urquie

Urquie is a semidwarf, awned, white-chaffed, soft white spring wheat. Urquie is resistant to lodging. The test weight of Urquie is equal to that of Fielder and about two pounds more than Twin and Dirkwin. Urquie yields competitively in the irrigated areas of Washington with other soft white spring wheat varieties. Urquie has moderate high-temperature adult plant resistance to prevalent races of stripe rust but is susceptible to leaf rust, highly susceptible to stem rust and moderately susceptible to mildew. Milling and baking qualities are excellent. Production should now be limited to areas in which these diseases are not a problem.

Urquie was developed by Washington State University and USDA-ARS.

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 rusts. Wampum has excellent milling and bread baking qualities.

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.

Borah

Borah is a bearded, white-chaffed, semidwarf wheat released in 1974. Compared to Wampum, maturity is 2 days earlier, and height is about 3 inches shorter. Borah is resistant to leaf rust and stem rusts but moderately resistant to currently prevalent races of stripe rust. Borah has good milling and baking qualities.

Spring Barley

Steptoe

Steptoe is a 6-row, rough-awned, spring non-malting 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.

Advance

Advance is a 6-row spring malting variety. The variety has low or no cold tolerance and, therefore, it 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.

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.

Vanguard

Vanguard is a 2-row malting barley recommended for nonirrigated areas. It has good lodging resistance. Vanguard matures about the same and is the same height as other 2-row varieties. It is a 2-row, spring barley with rough awns. The seed size is slightly smaller than that of Piroline. The malting quality is slightly below Klages and Kimberly but the yield has been higher on nonirrigated tests.

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.

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.

Kombar

Kombar is a 6-row, spring, non-malting barley developed primarily for irrigated production by the Northrup-King Company. Kombar has semi-smooth awns, mid-season maturity and a moderate test weight. Its yield performance is similar to Steptoe's under irrigation. It has relatively short and stiff straw giving it good lodging resistance. It is recommended for irrigated production. Kombar has nutritional value similar to Steptoe.

Gus

Gus is a 6-row, spring, non-malting barley also developed for irrigated production. Gus has rough awns, mid-season maturity and a moderate test weight. It is short and stiff-strawed with good lodging resistance. It is recommended for irrigated production. Its yield record is similar to Steptoe's under irrigation. Gus has nutritional value similar to Steptoe's. Gus was developed by Western Plant Breeders.

Kamiak

Kamiak is a 6-row winter barley. It has produced high yields in tests. Kamiak has good winter-hardiness. 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.

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.

Oats

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 Washington—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.

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.

SOFT WHITE WINTER WHEAT IMPROVEMENT

Clarence J. Peterson Jr., Steven Hayward, Duane Moser, and Patricia S. Green

General Results

Washington farmers harvested 167 million bushels of wheat in 1983 for a record average yield per acre of 63.7 bushels. Excellent growing conditions prevailed throughout the crop year. Cereal diseases were a problem and limited production. The major diseases were *Cercosporella* foot rot, barley yellow dwarf, stripe rust, leaf rust, and stem rust.

Objectives

1. Develop soft white winter wheats with the disease resistance needed to maintain wheat production in Washington and eliminate or reduce the need for chemical control of diseases.

2. Improve the emergence and other agronomic characteristics needed to improve the adaptability of soft white semidwarf winter wheats.

3. Maintain or improve the milling and baking quality of the soft white winter wheats.

Progress

New Varieties

The semidwarf club wheat WA006698 was approved for release. It is the first soft white club winter wheat with combined resistance to leaf rust, stripe rust, and powdery mildew. WA006698 has high yield potential and produces well where foliar diseases for which it has resistance are prevalent. It usually outyields other club wheat varieties except Tyee. The test weight of WA006698 is 0.7 to 1.5 lbs/bu heavier than other currently grown club wheat varieties.

Promising Lines

WA006912 (Brevor/CI015932//Nugaines) was approved for preliminary increase in 1983-84. It is a semidwarf soft white winter wheat that is resistant to the local races of stripe rust and common bunt. WA006912 has some tolerance to flag smut, *Cephalosporium* stripe and leaf rust. WA006912 matures 2 to 3 days later than Daws. It is equal to Nugaines in winterhardiness. WA006912 has averaged 69.9 bu/ac over 63 site/years of tests. It averaged 1.6, 3.1, and 7.3 bu/ac more than Stephens, Daws and Nugaines, respectively.

Four new selections were entered in the 1983-84 Western Regional Winter Wheat Nursery. Three selections (WA007168, WA007169, and WA007170) are soft white common semidwarf wheats and one selection (WA007167) is a soft white semidwarf club wheat. They were among the top producing lines in the past two years.

WA007047, a soft white common semidwarf winter wheat, has had an excellent yield record for the past three years. It could be the next line that is proposed for release. WA007047 is resistant to the local races of stripe rust and common bunt. It is moderately resistant to leaf rust and susceptible to *Cercosporella* foot rot. WA007047 is similar to Stephens in winterhardiness.

Cereal Diseases

Data was obtained on the following cereal diseases in 1982-83: *Cercosporella* foot rot, stripe rust, leaf rust, and stem rust. A new race of stripe rust developed on four club wheats (Faro, Barbee, Jacmar, and Moro) that were previously resistant to the local races of stripe rust. Stem rust appears to be on the increase and we may need to develop resistant varieties.

Emergence

Approximately 1000 lines were evaluated for emergence and coleoptile length in 1982-83. Many of the new semidwarf selections equal Luke in emergence.

Yield

Table 1. The following table contains the yield data (bushels/acre) on 9 winter wheats grown at 5 locations in Washington during the past 5 years.

	1979	1980	1981	1982	1983	Avg.
Common Wheats						
Nugaines	52	62	53	80	74	64
Daws	60	66	62	87	84	72
Stephens	49	56	74	85	93	71
Lewjain	61	76	63	85	94	76
Hill 81				87	87	
WA006912	62	69	72	75	89	73
Club Wheat						
Tyee	59	66	59	84	79	69
Crew	57	65	58	83	82	69
WA6698		70	70	82	79	

Table 2. Agronomic and Disease data on 10 soft white winter wheats.

Varieties	Emergence Index	Winter Hardiness	Maturity	Test Weight	Common Bunt	Dwarf Bunt	Leaf Rust	Stripe Rust	Cephalosporium Stripe
Common									
Nugaines	5*	6	medium	8	R**	S	S	MS	MR
Daws	4	8	medium	7	R	S	MS	MR	MS
Stephens	5	2	early	7	R	S	MS	R	S
Hill 81	5	5	medium	7	R	S	MS	MR	MR
Lewjain	6	5	late	7	R	R	MS	R	MR
WA006912	5	5	med-late	7	R	S	MS	MR	MS
WA007047	5	5	medium	7	R	S	MR	R	MS
Club									
Tyee	5	5	medium	5	MR	S	S	R	MS
Crew	6	5	medium	6	MR	S	MR	MR	MS
WA006698	6	5	medium	7	MR	S	R	R	MS

*1=poor — 10=excellent
**R=resistant, MR=moderately resistant, MS=moderately susceptible, S=susceptible

HARD RED WINTER WHEAT BREEDING AND TESTING

E. Donaldson, M. Nagamitsu, and M. Dalos

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, high yielding, disease resistant varieties through varietal development and testing of advanced selections and varieties developed elsewhere. In varietal development, emphasis is placed on combining the higher yield potential of soft white and other winter wheats with better adapted varieties and selections of good quality hard red winter wheats. Crosses are made to include a wide genetic background in the breeding program. Different types and sources of disease resistance are used to help prevent having only one source of resistance to any given disease. Many of the sources for disease resistance, winterhardiness, quality, or yield are not well adapted to the area and require one or two series of crosses (parent building) to get the desirable features of high quality and disease resistance into adapted varieties for the low rainfall area.

Promising Selections

Selection WA 6816 has been approved for preliminary increase. WA 6816 is a tall semidwarf hard red winter wheat. In 17 yield trials in the expected area of production, it yielded 12% more than Hatton and 30% more than Wanser, with 0.5% less flour protein and a superior loaf volume. It appears to have adequate stripe rust resistance, but is weak in leaf rust resistance. Emergence is similar to other semidwarfs. Winterhardiness appears to be less than the hard red winter wheats currently grown.

WA 6820 (developed by Dr. G. W. Bruehl) is a semidwarf hard red winter wheat with good snow mold tolerance and fair TCK resistance. Preliminary tests indicate the quality is satisfactory. It has a good yield record in the Waterville nursery. A tendency toward weak straw and a susceptibility to stripe rust appear to be its major weakness.

Results

Crusting caused by late summer rains during seeding required reseeding on considerable acreage in the wheat summer fallow area. A very mild winter with above normal rainfall resulted in exceptional yields. Late seeded wheat, however, was not capable of responding to the more favorable conditions as the earlier seeded wheat. This was observed in the Waterville and Lind nurseries. Foliar diseases were prevalent. Weeds, particularly downy brome (cheatgrass), were a severe problem in many wheat fields. Dwarf smut, *Cercosporella* foot rot, and barley yellow dwarf were evident in localized areas. Snowmold was evident, but not sufficiently severe to create the need for reseeding.

Winter conditions on the 1984 crop resulted in the need for reseeding. The Waterville nursery shows considerable snowmold damage. The nurseries at Lind show a moderate amount of winter (cold temperature) injury with a few of the weaker selections being eliminated. Table 6 shows the amount of winter injury on some released varieties and advanced selections.

Table 1. Summary of agronomic characteristics of winter wheat varieties grown near Harrington in rod row nurseries, 1952-83.

Variety	Av. Test wt.	1983 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. years grown
Nugaines	61.6	43.5	41.8	138	18
Luke	60.8	44.2	44.9	149	15
Daws	60.3	43.3	44.6	140	10
Stephens	60.0	51.3	46.1	145	10
Lewjain	60.7	52.3	49.3	160	7
Hill 81	59.3	48.6	54.0	169	2
Moro	59.0	44.8	41.4	136	18
Faro	58.9	50.0	47.0	148	10
Crew	59.0	53.8	55.2	168	6
Tyee	58.5	52.6	52.0	165	8
WA 6698	59.5	53.1	55.7	176	4
Hatton	63.0	45.8	45.5	145	8
Kharkof	61.1	28.1	33.7	100	30

Table 2. Summary of agronomic characteristics of winter wheat varieties grown at Lind in rod row nurseries, 1952-83.

Variety	Av. Plant ht.	Av. Test wt.	1983 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. years grown
Nugaines	26	61.3	18.9	35.9	126	19
Luke	26	59.7	19.8	32.6	127	15
Daws	29	59.1	23.0	34.2	135	10
Stephens	28	58.1	20.8	31.9	130	11
Hill 81	25	58.5	21.4	24.4	116	2
Lewjain	26	59.0	20.6	32.2	143	7
Moro	32	58.4	28.2	35.4	125	20
Faro	27	57.7	18.0	35.2	125	10
Crew	27	57.9	24.9	35.6	156	6
Tyee	27	58.2	12.8	32.4	118	8
WA 6698	27	60.2	16.4	37.4	156	4
Wanser	31	61.6	21.0	32.8	119	20
Hatton	31	62.4	24.1	31.5	137	8
WA 6816	28	60.4	34.0	36.5	164	3
Weston	34	61.3	26.4	30.8	135	6
Kharkof	33	60.5	19.0	28.5	100	29

Table 3. Summary of agronomic characteristics of winter wheat varieties grown at Horse Heaven Hills in rod row nurseries, 1951-82.

Variety	Av. Test wt.	1982 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. years grown
Wanser	60.3	27.6	39.9	116	14
Hatton	62.5	25.0	42.7	143	6
Weston	62.0	24.7	37.3	132	3
Kharkof	60.1	24.0	33.6	100	21

Table 4. Summary of agronomic characteristics of winter wheat varieties grown near Connell in rod row nurseries, 1975-83.

Variety	Av. Test wt.	1983 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. years grown
Nugaines	62.1	30.2	35.1	120	7
Daws	60.6	33.1	36.9	134	6
Stephens	59.9	31.8	37.3	136	6
Lewjain	61.6	26.8	26.8	137	1
Moro	59.5	33.7	38.1	131	7
Faro	59.3	33.4	37.4	136	6
Barbee	60.0	32.3	34.1	136	5
WA 6816	60.3	30.4	30.4	155	1
Wanser	62.3	22.8	33.8	116	7
Hatton	63.3	28.6	36.1	131	6
Weston	63.1	23.2	36.3	137	4
Kharkof	61.5	19.6	29.1	100	7

Table 5. Summary of agronomic characteristics of winter wheat varieties grown at Waterville in rod row nurseries, 1952-83.

Variety	Av. Test wt.	1983 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. years grown
Luke	61.0	29.6	47.5	149	11
Stephens	59.4	28.9	46.2	160	5
Lewjain	61.8	26.8	47.0	167	3
Moro	59.2	29.7	43.7	129	14
Faro	58.9	46.8	47.3	151	4
Crew	60.6	50.0	51.6	159	2
Tyee	59.6	29.9	46.9	173	4
Barbee	59.1	29.4	44.9	155	5
Wanser	62.0	22.8	39.6	116	15
Hatton	63.6	28.6	43.4	150	5
WA 6816	61.0	30.5	43.4	154	3
Weston	62.6	23.2	37.0	136	4
Kharkof	61.1	19.6	33.4	100	24

Table 6. Estimated percent winter injury for released varieties and selected advanced lines in the 1984 Western Regional Nurseries at Lind, WA.

Soft White	% Injury	Hard Red	% Injury
Kharkof	1	Kharkof	5
Daws	14	Hatton	10
Luke	13	Weston	11
Sprague	11	Neeley	7
Lewjain	16	Manning	14
Hill 81	18	Winridge	7
Crew	16	Wanser	10
Barbee	19		
Jacmar	6	WA 6816	17
Moro	10	WA 6820	12
Nugaines	12		
Stephens	23	WA 7171	9
Tyee	15	WA 7172	6
		WA 7173	12
WA 6698	14		
WA 6819	6		
WA 6912	19		
Phoenix	97		

GENETIC AND ADAPTATION STUDIES IN BREEDING WHEATS FOR DIVERSE ENVIRONMENTS

R. E. Allan, J. A. Pritchett, L. M. Little, J. Poulos, and K. K. Hwu

Breeding wheats for conservation tillage. Comparisons were made on 5 to 9 traits between no-till and tilled plots of 80 to 120 varieties, selections and genetic populations at two sites in 1983. Tillage practice consistently affected heading date, percent stand, plant height and grain yield. No-till increased grain yields by 24% at one site but reduced it by 15% at another site. In contrast to the 1982 results, the 1983 tests on 18 genetically unfixed populations showed few significant shifts in several measurements whether these populations were grown under no-till or tilled culture. We want to test the theory that by growing genetically unfixed populations repeatedly on no-till we can select out lines with superior fitness and adaptability to no-till. Mr. Kae Kang Hwu has taken over this project as part of his Ph.D. research.

Do blends of wheat varieties have an advantage in no-till or conventional till mangement? Preliminary yield comparisons were obtained on Daws (D), Stephens (S), Lewjain (L) and Nugaines (N) and their 11 possible mixtures or blends under both no-till and till culture at Spillman Farm and Colton in 1983. When compared to the varieties, the yields of the various blends were higher, equal, or lower in 22, 69 and 9% of 176 comparisons, respectively. Most of the blends yielded comparably to the highest yielding variety in 3 of the 4 tests. DSL was the only blend that yielded equal to the highest yielding variety in every test and across all tests. Blends of DL and DLN also had high overall yields. Lewjain and Daws were the highest and lowest yielding varieties, respectively, and they were components of the three highest yielding blends. In the tilled test on Spillman Farm blends DS and DN actually exceeded the yields of their respective varieties indicating that these two blends had superior yield fitness compared to their component varieties.

Unexpectedly, the blends appeared to be less adapted to no-till than the varieties. At Colton, where no-till increased yields, the increase for the blends averaged 17% vs. and average of 33% for the varieties. At Spillman Farm where no-till decreased yields, the blends were reduced an average of 13% compared to 3% for the varieties.

Shorty-two-gene semidwarf wheats. Someday we may be growing even shorter wheats than our current semidwarfs, at least for some management systems and soil conditions. Why? The main reason would be to increase the harvest index of our wheat crop. Harvest index, or HI as it is called, is the percent grain yield that is produced in proportion to the total biological yield of the crop. Biological yield is simply the grain weight and the straw weight together. The semidwarfs Nugaines, Daws and Stephens have HI values ranging from 36 to 43% versus 26 to 33% for the standard height varieties of Omar, Marfed and Golden. But the shorty-two-gene semidwarfs with heights that are 15 to 25% shorter than our current semidwarf varieties have even larger HI values which usually range from 45 to 52%.

High HI values mean a more biologically efficient wheat plant. Plants with high Hi values partition a greater proportion of photosynthetic products into grain and proportionately less into straw. More grain is produced per unit of straw. Plants with high HI values usually use less water and plant nutrients per unit of grain produced than those with low HI values.

The big drawback to high HI shorty wheats has been they have not been competitive in yield with our current semidwarfs. Several years ago we started a project to increase the yield potential of the shorty wheats. We have now gone through two cycles of recurrent selection and have evidence that we can get high yielding, high HI, shorty wheats.

Tests conducted in 1982 and 1983 on 25 to 50 of our most promising shorty lines showed that 21 yielded equal to or greater than Daws when yields are averaged over five trials. Daws, Lewjain and Nugaines averaged 91.4, 90.8, and 87.3 bu/ac across these five tests. The best shorty wheats had overall averages ranging from 85.6 to 98.7 bu/ac and the 21 lines averaged 92.0 bu/ac. The top shorty wheat yielded 8 to 13% more than Daws, Lewjain, and Nugaines and several yielded from 1 to 5% more than these varieties.

We now feel certain we can steadily improve the yield potential of shorty wheats through continued recurrent selection. But these lines still lack potential as varieties. Most of them have poor milling quality and some have inadequate resistance to rusts and powdery mildew. As a group they tend to emerge poorly. We are now trying to select away from these problems among our new advanced shorty wheat candidates.

BREEDING WHITE WHEATS RESISTANT TO SPROUT DAMAGE

R. E. Allan, L. M. Kruger, G. L. Rubenthaler, J. A. Pritchett, and L. M. Little

Preharvest sprout damage continues to be a serious problem to U.S. Pacific Northwest wheat production. Damage was extensive in 1983. The two varieties, Brevor (Washington) and Vakka (Finland), are our main sources of resistance to sprout damage. We allowed 157 F3 and F4 offspring and their parents of a cross between Brevor and Vakka to receive repeated rain damage during August to November of 1982 and 1983. The 1982 test received 18 episodes of rain totaling 3.5 inches and the more severe 1983 test had 30 episodes of rain totaling 6.8 inches. We harvested on 26 October in 1982 and on 18 October and 21 November in 1983.

Grain samples of the offspring and the parents were checked for alpha-amylase activity using a colorimetric method developed by the U.S. Grain Marketing Research Lab. Low and high alpha-amylase activity indicates low and high sprout damage, respectively. The heritability of low alpha-amylase activity was moderately high at 55 based on single test data. When heritability was estimated on the additive gene effects, however, the values were low ranging from 13 to 24. Low additive gene heritability means it will not be easy to select for pre-harvest sprouting resistance because environmental conditions greatly affect the expression of this trait. The distribution of the offspring for alpha-amylase activity indicated that Brevor and Vakka probably have different genetic systems governing sprout resistance. The evidence suggested a minimum of three genes control alpha-amylase activity in this cross, but none of the offspring surpassed Vakka for low alpha-amylase activity.

After 6.8 inches of prolonged rain in 1983, 33 offspring remained essentially undamaged with alpha-amylase scores of <0.049 Du/g which is equivalent to a falling number score of >300. These lines are being used in further crossbreeding with adapted high yielding lines.

DEVELOPING WHEATS WITH COMBINED RESISTANCE TO DISEASES OF EARLY SEEDING

R. E. Allan, C. J. Peterson, R. F. Line, and J. A. Pritchett

Our 1983 tests verified the 1981 and 1982 results and showed that several lines continue to express high resistance to strawbreaker or *Cercosporella* foot rot. This resistance is derived from a goat grass (*Aegilops ventricosa*). Four lines designated as WA 7163, WA 7164, WA 7165, and WA 7166 yielded 137,138, 106 and 114 bu/ac, respectively, in a moderately severe foot rot test where Stephens, Tyee, Lewjain and Nugaines yielded 81, 72, 69 and 64 bu/ac, respectively. These four resistant lines had foot rot induced losses of 0 to 8% compared to 26 to 39% for the four varieties.

The lines are semidwarf soft white winter wheats. They carry either Hill 81, Tyee, Raeder or Hyslop in their parentage in addition to the goat grass parent. All four have been placed in the regional performance tests.

These lines are either resistant or heterogeneous for resistance to the currently prevalent leaf and stripe rust races in this region. WA 7164 and WA 7166 expressed resistant and moderately resistant reactions to a severe attack of stem rust at Spillman Farm in 1983. The other two lines are susceptible. The four lines apparently have adequate coldhardiness since they survived a moderately severe test at Ritzville this winter. Quality tests have been mixed but WA 7165 may be marginal for milling quality. We have made reselections among these lines to stabilize their leaf rust resistance and quality attributes.

RUST GENETIC STUDIES

R. E. Allan, C. A. Griffey, J. A. Pritchett, L. M. Little, L. M. Kruger

Broadening the genetic base of stripe rust resistance. The key to successful breeding for resistance to stripe rust is to use a broad genetic base of resistance. Last year Barbee, Faro, Moro, Jacmar and several hard red winter varieties were all compromised when CDL5 and related races attacked them. We have just completed a genetic study involving 46 Lemhi 53 derived near-isogenic lines of 16 different families. The families obtained stripe rust resistance from 14 different sources around the world. The lines were placed in three resistance categories: those that have race-specific seedling resistance alone, those with non-race-specific adult resistance alone and lines that had both types of resistance.

Among lines of 8 families with seedling resistance we learned that one to two genes controlled their resistance and a minimum of 3 but no more than 7 different genes were represented among all lines. Lines deriving resistance from two sources (Magnif 27 and T.spelta/Coastal) had a unique type of complementary seedling resistance; neither parent had resistance but offspring from crosses between them expressed resistance. This is a rare form of resistance which has proven to be very durable to other kinds of diseases.

Adult resistance tended to be governed by more genes than seedling resistance. Some crosses among different resistant lines suggested that 2, 3, and even 4 genes controlled adult plant stripe rust reaction. The gene pool represented by these 16 families had greater genetic diversity for adult plant resistance than for seedling resistance.

We have advanced our early generation lines with seedling resistance from all of these sources but one. We have not made extensive use of four of the sources of adult resistance. Our next objective is to introduce these new genes for adult resistance into adapted parental lines. We will make a special effort to exploit the unique complementary seedling resistance as well.

Losses caused by stem rust. Last year we discovered that several of our Lemhi 53 derived near-isogenic lines of wheat carried genes for either resistance or susceptibility to black stem rust. These paired sib lines were resistant to stripe and leaf rust so it gave us a chance to accurately determine how much damage stem rust caused in 1983 to spring wheat at Spillman Farm.

The black stem rust susceptible lines had yields that ranged from 5 to 30% less than their resistant sib lines and they averaged 17% lower yield. The susceptible sibs also had 0.1 to 1.4 lb/bu lower test weights (Avg. 0.8 lb/bu less) than their resistant counterparts. Their plant heights were also slightly shorter by 1 to 2 cm than their resistant sibs.

Clearly black stem rust has the potential to cause serious losses to wheat in our region. Breeders can no longer ignore breeding for resistance to stem rust!

Release of Tres, WA 6698 Soft White Club Winter Wheat. The semidwarf club wheat, Tres, was approved for release by ARS-USDA and the Agricultural Exp. Stations of Washington, Oregon and Idaho. It is the first soft white winter wheat with combined resistance to leaf rust, stripe rust, and powdery mildew. Tres has high yield potential and produces well where foliar diseases for which it has resistance are prevalent. Tres usually outyields other club wheat varieties except Tyee. It has been extensively tested in regional and state trials for 4 to 6 years. In 96 Washington State test-years the average yield of Tres has been 15, 14, and 13% greater than that of Nugaines, Faro, and Barbee, respectively. the test weight of Tres is 0.7 to 1.5 lbs/bu heavier than other currently grown club wheat varieties.

STRAWBREAKER FOOT ROT

T. D. Murray and G. W. Bruehl

Several fungicides are being tested for the control of foot rot. Three compounds, Baytan, Epic, and Ronilan, are used as seed treatments; and Benlate, Mertect-340-F, and Topsin-M are used as foliar sprays. In addition, we have several new compounds and formulations that we are trying. In past trials with Benlate, Mertect, and Topsin, Benlate was more effective over a wider range of application dates than Mertect in protecting wheat against foot rot.

Preliminary results from a genetic study of resistance indicate that inheritance of resistance to foot rot is controlled by many genes. We are continuing to study the genetic control of disease resistance. This year we have the F_1 progeny from crosses between resistant and susceptible parents in the field. The preliminary results also show that a wide, heavily lignified hypodermis (mechanical tissue in the stem) is an important component of resistance.

We are studying the effect of foot rot on wheat yield components in order to determine the effect environment has on resistance. Under a severe disease level, tillers are killed, number of seeds per head and seed weight are reduced. Under a mild disease level, number of seeds per head and seed weight are reduced. Disease resistance ratings for the six varieties used varied from year to year, but the ranking of the varieties was the same, which indicates that environment affects disease severity, but all varieties are affected the same way. A resistant variety should, therefore, be resistant regardless of environment. We will continue to study this aspect of resistance.

TAKE-ALL AND *PYTHIUM* ROOT ROT

R. J. Cook and D. M. Weller
USDA, Agricultural Research Service

Take-all and *Pythium* root rot are the two main root diseases of wheat in eastern Washington. Both are favored by recropping (wheat after wheat or barley) and reduced tillage.

Take-all is a problem mainly for irrigated wheat, although the disease has caused significant loss in the Palouse in recent years in annual-cropped, no-till wheat. Symptoms include blackened roots, and the lower 1-2 inches of the stems of severely diseased mature plants 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 crown and lower stem tissues, plants die from lack of water and show "white heads." The fungus lives in the crop residue and is especially successful when crowns of infected plants from one season are left undisturbed (as with no-till); the fungus can then grow from a large food base directly into the plants of the succeeding crop.

Pythium root rot is a problem mainly on late-seeded winter wheat. The fungus lives as spores in the soil, and may thin a stand of wheat by causing seed decay or seedling blight before or shortly after emergence. *Pythium* also damages the feeder roots of the plant, resulting in uneven height, less tillering, and smaller heads; the plants also appear poorly nourished. The results are now clear that the 15-25% yield response in our soil fumigation trials conducted over the past 10 years is due mainly to *Pythium* control, which demonstrates the importance of this fungus. *Pythium* is more active when straw and chaff are left on the soil surface (as with no-till), or blended with the top few inches of soil (as with minimum till). The fungus is favored as a pathogen by cool, wet soil, typical of soil with surface residues, and it uses nutrients from straw and chaff as a food source.

The best control for take-all is crop rotation, i.e., do not grow wheat or barley in the same field more than one every two years. Potatoes, alfalfa, corn, and beans are all nonhost crops. Irrigation water supplied in large by infrequent applications e.g., 3-4 inches every 7-10 days (as is possible with rill or solid-set systems) will also help keep take-all in check. Pivot irrigation is more favorable to the fungus. Thorough tillage helps control the disease by accelerating the death rate of the fungus. Tillage is an option for take-all control only if a rotation is not followed; but the best option is crop rotation. A major objective of our research is to control take-all without crop rotation, under pivots, and with less tillage. Good phosphorus fertility can give some control. The disease eventually declines with prolonged recropping (take-all decline), because of a natural biological control. Unfortunately, rotation crops break this cycle so that when wheat is again grown, severe take-all will occur again, and must then decline again. 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. Some significant field results have been obtained with this treatment in small plots, and pilot tests are underway in a five-acre trial near Ephrata and a 3-acre trial near Mt. Vernon, Washington.

Work on *Pythium* control involves a search for a chemical or biological seed treatment. Several compounds have been found to protect against the seed rot and seedling blight phases of this disease. However, the compound must be systemic or must somehow move or be placed into the root zone beneath the seed to be effective against the root damage caused by *Pythium* . Unfortunately, many *Pythium* spp. are involved in this root-rot complex and a compound may be effective against some but not all species. Thus, Apron (metalaxyl) controls only about half of the species, which makes up a large percentage of the total *Pythium* population in some fields of the Palouse. Nevertheless, Apron as a seed treatment has given significant field increases in wheat after wheat or barley with conservation tillage. As for take-all, a biological seed treatment is showing promise in preliminary field trials.

The overall thrust of our program is to improve the health of roots of wheat and barley grown in the intensive management systems. Soil fumigation as a research tool has demonstrated that improvements in root health can increase yields, and possibly also reduce the rates of fertilizer since healthy roots are more efficient than diseased roots in uptake of plant nutrients. With the exception of trials at Lind, all of our work is off station. Special arrangements can be made if desired to see these trials.

CEPHALOSPORIUM STRIPE

G. W. Bruehl, R. Machtmes, C. Love

Cephalosporium stripe (fungus stripe) was severe in a nursery at Pullman. We obtained data on percent of infested straw and weight of infested straw in each variety. The pathogen, *Cephalosporium gramineum,* lives in infested straw between wheat crops, so the straw with fungus in it is the source of inoculum for future crops. The most susceptible wheats not only suffer the greatest yield loss but they produce the most inoculum for future crops, so resistance would have double value, first to lose less grain directly, and second, to produce less infested straw.

The problem we have, and it is serious, is that some wheats are relatively resistant in some seasons, susceptible in others. Luke and Lewjain did poorly in our 1982-1983 plot. In some years they do well. Stephens, McDermid and Hyslop are always poor, and Nugaines is dependably intermediate. Selection 80-112 has varied from intermediate to very good. Apparently the type of winter affects the way the disease attacks some wheats.

Production of inoculum of *Cephalosporium gramineum* by wheat varieties at Pullman in 1982-1983 season.

Variety	Stems infected, %	Weight of infested straw, lbs/acre
McDermid	61	1846
Hyslop	59	1830
Stephens	57	1794
Luke	40	1676
Selection 101	57	1675
Lewjain	33	1548
Brevor	49	1391
Nugaines	40	1356
Burt	43	1148
Daws	29	879
Winridge	25	745
Sprague	18	492
Selection 80-112	11	291
Least significant difference, 5% level	11%	526 lbs

Cephalosporium gramineum enters the roots of winter wheat during late fall, winter, and early spring. Wounds from freezing soil accentuate infection. In greenhouse studies, in which no wounding occurs, a few plants become infected. The ability to enter a plant without wounding, though it would not lead to serious disease loss, may assist the fungus in surviving in years unfavorable to stripe. A few diseased plants could keep the fungus from dying out. It survives in straw only until the straw is rotted and its spores live only a few months in soil. This is the reason rotation with spring grains, lentils, or peas is so useful. Spring-sown crops should be long enough to reduce the fungus to safe levels.

Indications are strong that soil acidity favors Cephalosporium stripe.

SNOW MOLDS ON WINTER WHEAT

G. W. Bruehl, R. Machtmes, D. Jacobs

We obtained useful resistance ratings on several winter wheats on the David Peterson Ranch, west of Mansfield, Douglas County, in 1982-1983. One selection, 79-177, was more resistant than Sprague. It does not have satisfactory quality but it has better straw than Sprague and should be a useful parent.

Mr. Peter Goldmark, east of Okanogan on the Colville Indian Reservation, seeded drill strips on high production land. The stand was perfect, but essentially no snow mold developed. Good yield and lodging data were obtained. Selection 77-136 yielded 84 bushels per acre with 3% lodging. WA 6819 yielded 83 bushels with 5% lodging. Lewjain yielded 77 bushels with 0 lodging, Sprague yielded 71 bushels with 30% lodging and Daws yielded 70 bushels with 0 lodging. We are indebted to Mr. Goldmark for seeding and harvesting these wheats.

WA 6819 yielded 51 bushels and Sprague yielded 45 bushels per acre in Dr. Clarence Peterson's nursery at Coulee City. WA 6819 did poorly in most nurseries in Washington. It may have narrow adaptation.

TYPHULA INCARNATA ON WINTER BARLEY

G. W Bruehl and R. Machtmes

Typhula incarnata is the fungus that produces reddish-brown resting bodies, sclerotia, in the crowns of winter wheat and barley, particularly in the dryland areas of northern Franklin County across Adams and into Lincoln County. The sclerotia look like little radish seeds. We hoped to increase the area in which winter barley could be safely grown by obtaining resistance to this fungus. Barley must survive both cold and fungi.

For three years we have grown winter barleys in Harrington soil outdoors at Pullman, and the results were different every year. It is apparent now that *T. incarnata* is a weak pathogen and it is serious only on barley injured in some way. With mild winter injury, not enough to damage healthy barley, the pathogen is severe. Without injury, the pathogen does little damage. We have abandoned this effort.

Experimental plots acknowledgments:
David C. Peterson, Mansfield, Douglas Co.
Peter Goldmark, Okanogan, Okanogan Co.

CONTROL OF STRIPE RUST AND LEAF RUST OF WHEAT

Roland F. Line
USDA, Plant Pathology

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 as larger, red-brown, diamond-shaped pustules on the leaf surface and stems. 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. In the late 1950's and early 1960's stripe rust caused losses in excess of 50%. Since 1963, destructive epidemics have occurred in fields of susceptible varieties in 16 of the last 21 years. In 1981, stripe rust reduced yields by more than 20%, and in 1983, stripe rust reduced yields by more than 15%. Without development of resistant varieties and emergency registration of a new fungicide, Bayleton, for rust control, losses would have exceeded 50% in 1981. Leaf rust has become increasingly more important since 1962. 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. In 1974, losses in Twin spring wheat exceeded 50%. Since then, leaf rust caused severe losses in 1975, 1976, 1978, 1980, 1981, and 1983. In 1983, losses caused by leaf rust in some irrigated fields exceeded 60%. Much of the losses caused by leaf rust in 1983 could have been reduced by timely application of a fungicide. Stem rust usually appears very late in the season and seldom causes damage. However, in 1981, 1982, and 1983 it caused some damage to wheat in eastern Washington, especially in late maturing fields. In 1983, wet weather in June and July provided a more favorable environment for stem rust and delayed crop maturity. The stem rust pathogen does not usually survive on wheat plants during the winter, but depends upon the common barberry for completion of its life cycle. Spores produced on the barberry are the source of inoculum for the wheat in the spring. Therefore, elimination of the barberry should eliminate the disease.

Because of the greater importance of stripe rust and leaf rust, most of my research is on control of those diseases. The major emphasis of research is on: (1) monitoring the diseases to determine where they are, what wheats are vulnerable, and the potential importance of new races; (2) identifying and utilizing various types of resistance; (3) evaluating fungicides at various rates and schedules for control of rusts; (4) studying the factors that contribute to rust epidemics; and (5) determining the amount of damage caused by the rusts so that priorities can be determined. The research is conducted at several field sites throughout the region and under controlled conditions in the greenhouse.

Monitoring rust. We must monitor the rusts and identify races to forewarn growers and wheat breeders of its appearance, distribution, and severity; determine vulnerability of varieties to new races; and determine how races evolve. The monitoring program involves: (1) planting trap plots, consisting of varieties that differentiate races and varieties with various types of resistance at sites throughout the region, and (2) collecting rust specimens and testing them on selected wheats under controlled conditions. Races of rust are identified by their ability to attack certain varieties. New races can arise by mutation and thus, are able to attack varieties that were previously resistant.

At least 32 races of stripe rust have been identified. Most stripe rust races identified in 1983 were virulent on Fielder, Fieldwin, Sterling, and seedlings of Walladay, World Seed 1, Nugaines, Daws, Hyslop, McDermid, and Luke. Races virulent on Jacmar, Moro, Faro, Barbee, Raeder, and many of the hard red winter wheats from southern Idaho and Utah were found for the first time in central Washington where they caused severe losses, especially near Lind and Ritzville. Therefore, those varieties will be extremely vulnerable to stripe rust in the future. A new race was also detected on Tyee. Seedlings of Tyee are very susceptible to the race, but the adult plants have some resistance. Races that were virulent on Paha and Yamhill and seedlings of Stephens were also present in 1983. Predominant races of leaf rust in the region are virulent on all winter varieties, except a component of the multiline, Crew, and all spring wheats, except World Seed 1, Wampum, Wared, and Waverly.

Resistance to rust. Research on resistance involves identifying new types and sources of resistance, understanding how resistance works, incorporating resistance into adapted wheats, and developing methods of using resistance. Research on resistance to stripe rust and leaf rust is being conducted at several field sites where the rusts occur and under controlled environmental conditions. Several types of resistance to stripe rust and leaf rust have been identified. Some varieties have a type of stripe rust resistance that is effective against all races at high temperatures late in the growing season but not at low temperatures early in the season. They have high-temperature, adult-plant resistance. Gaines, Nugaines, Wanser, McCall, Hyslop, McDermid, Luke, Daws, Stephens, Lewjain, Hill 81, Urquie, Wampum, Waverly, and the newly released varieties from Washington all have various degrees of the high-temperature adult plant resistance. This type of resistance is considered to be durable because it doesn't "break down" to new races. Some types of leaf rust resistance are "slow rusting" and do not allow the rust to increase as rapidly. The various types of leaf rust and stripe rust resistance are being incorporated into new varieties. Studies on the genetics of stripe rust resistance and leaf rust resistance are presently being conducted in the field and greenhouse; this information should be useful in developing varieties with improved resistance.

Fungicides. In the past, fungicides were not considered economically practical for control of rust. However, we have identified new systemic fungicides that can even stop the rust from increasing once it is present on the plant. In 1981, emergency registration of Bayleton was obtained, which resulted in increasing wheat production in Washington by more than 1,000,000 bushels. Bayleton is now fully registered for use on wheat for control of rust, and guidelines for its use have been developed. Studies are presently being conducted to determine the best time and amount of fungicide to apply and to determine how fungicides may be used in an emergency or in combination with resistance. New fungicides that have potential are also being evaluated, and a new seed treatment, Baytan, that has potential as part of a rust control program, is expected to be registered for use this year.

Relationship of rust to weather. A model based on the relationship of stripe rust to winter and spring temperatures has accurately predicted stripe rust epidemics since 1979. The model, based on data from Pullman, WA, was tested and modified using data from other sites in the Pacific Northwest. A site correction factor improved the predictive accuracy using negative degree days in the winter, and a method of identifying the beginning of spring growth using positive degree days provided additional accuracy. Based on the model, we expect that stripe rust will be less severe in 1984 than in 1983. Most severe rust should be in southeastern Washington and in fields of Jacmar, Moro, Faro, and Barbee.

Losses caused by rust. Selective fungicides and resistant varieties are being used to control rust in field plots at several sites. When rust severity and yields from the control plots are compared with rust and yield in noncontrolled plots, we are able to determine losses caused by the rusts. Studies on the relationship of yield to percent of the surface covered by rust show that less than 20% stripe rust or 30% leaf rust at dough stage reduces yield less than 10%, 20-60% stripe rust, or 30-55% leaf rust reduces yield 10-25% and more than 60% stripe rust or 55% leaf rust reduces yield more than 25%.

INHIBITORY BACTERIA ON WINTER WHEAT ROOTS

J. K. Fredrickson, H. Bolton, L. F. Elliott, and R. I. Papendick
USDA, Agricultural Research Service

Our studies show that large numbers of bacteria inhibitory to winter wheat growth can be present on winter wheat roots. Seeding into heavy wheat residues (till or no-till) seems to encourage the presence of these bacteria on the roots; however, we do not know why. In no-till seedings into heavy residues, severe stand loss can result in the chaff row. This happened in many seedings in the Palouse this past winter. These organisms may be a partial answer to the problem.

The bacteria are aggressive root colonizers and normally appear in large numbers on the roots after the plants break dormancy in early spring. We have sampled fields where all of these bacteria that are on the roots are inhibitory. While we do not have data to support it, we feel that crop rotation is very important. Our data indicate that roots from plants growing in a field that was fallow are colonized by fewer of the inhibitory organisms than roots from plants growing in an adjacent recrop area. The organisms appear somewhat specific. Isolates from winter wheat have much less effect on barley and little effect on oats, peas, and lentils.

In laboratory tests, some of the organisms inhibit winter wheat growth up to 75 percent of the noninoculated control. Plants inoculated in the field did very poorly when compared with noninoculated winter wheat plants.

The organisms are very unstable genetically and require special handling. They produce a toxin that is active against winter wheat plants and some bacteria. The evidence suggests the toxin is the primary cause of the deleterious effect by these organisms.

Work is proceeding on stabilizing the genetics of the organisms, determining the effect on the plant, measuring environmental conditions predisposing root colonization by these organisms, and identifying the toxin.

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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. However, extensive evaluation and screening trials are conducted also in the low rainfall area at the Dry Land Research Unit at Lind and under irrigation at the Royal Slope experimental farm near Othello. Smaller scale, but still substantial, research test plots are conducted via grower cooperation on the Dale Bauermeister farm near Connell (dry land), at the Kramer ranch near Harrington (dry land), and on the Phillips ranch near Cunningham (circle sprinkler irrigation). Extension-related trials 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 all research test locations. The uniform yield trials include Washington State soft white and hard red spring wheat nurseries of about 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. Non-replicated 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 several nurseries distributed by CIMMYT, such as the International Spring Wheat Yield and Bread Wheat Screening Nurseries, and the Uniform Regional Hard Red Spring Wheat Nursery. This group of nurseries plus crossing blocks supplement the base of resource material available for cross-breeding and rarely for direct utilization.

Certain of these final stage testing trials include lines also from research programs in Idaho and Oregon as well as private breeder materials. Of the WSU materials five lines are in their third year of testing, two in their second year, and four are new in 1984. Of the new lines in tests are lines resistant not only to the three rusts, but also to the hessian fly.

New Varieties and Their Characteristics

Waverly—released in 1981 by the states of Washington and Idaho after an over-winter increase in Arizona. Waverly carries both specific and adult plant resistances to both stripe and leaf rust diseases as well as resistance to stem rust. Adult plant resistance to stripe rust may be more stable against new races. Waverly is susceptible in the seedling stage to stripe and leaf rust, and seems to be more severely injured in the seedling stage by stripe rust than Urquie which has similar, but even less effective adult plant resistance. Fortunately, there is promise for the near future registration of a seed treatment to control rust diseases in the seedling stage. Waverly is moderately susceptible to powdery mildew, but mildew has not proved an important disease in our area. It has satisfactory pastry processing quality properties. Certified seed was in good supply in 1984.

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

1984 Research

Soft White Spring Wheats

Major emphasis in breeding SWS wheats has been to more fully exploit yield potential advances made by combining the best new lines in crosses to improve resistance to the Hessian fly, and to broaden their base of resistance to leaf and stripe rusts. Considerable progress has been made toward converting the whole of the SWS and facultative SWS breeding populations to H. fly resistance, through the close cooperation of Drs. K. Pike, WSU, Prosser, and J. Hatchett, USDA Manhattan, Kansas, and through the opportunity to increase materials in New Zealand. The New Zealand increases have been made possible through a related U.S.-N.S.F.-Japan Cooperative project and the STEEP program. Selections from crosses for H. fly resistance are in replicated yield tests and in Regional trials. Male sterile facilitated recurrent selections (MSFRS) breeding population were initiated. Some results from 1983 trials of current public and private varieties and advanced SWS selections are shown in Tables 1, 2, 3, 4. Table 5 shows 1983 data on some new hessian fly resistant SWS wheats.

Facultative Wheats

The 1983 fall-sown screening trial of facultative wheats allowed the identification of many new lines carrying even better cold tolerance and disease resistance than Walladay. New crosses have been made to bring in H. fly resistance and to further improve stripe and leaf rust resistance. Efforts also are aimed at combining both specific and non-specific types of resistance to the two rusts. New, extremely early Japanese winter wheats were obtained and used in breeding for earliness and hardiness.

Table 1. SWS Commercial Variety Nursery Yields (TW)

Entry/Loc	R.S.	P.	H.	L.
Fielder	110(64)	47(52)	37(60)	39(62)
Urquie	103(63)	61(57)	57(63)	43(63)
Dirkwin	120(61)	85(57)	58(60)	42(60)
Owens	120(64)	87(61)	58(63)	44(62)
Waverly	124(63)	85(58)	59(62)	42(60)
WS1	138(63)	77(54)	58(61)	40(59)
WS13	123(63)	64(55)	53(61)	40(60)
WS4120	112(64)	92(63)	55(64)	37(61)
WA6831	128(63)	89(60)	61(62)	41(61)
WA7073	132(65)	91(60)	58(63)	41(62)
WA7074	130(65)	87(61)	58(63)	40(62)

R. S. = Royal Slope (Irrigated)
P = Pullman
H = Harrington
L = Lind

Table 2. SWS Commercial Variety Nursery Suppl. Data

Entry	Heading (Dirkwin)	Pl. Ht(P)	Stripe Rust	Leaf Rust	Stem Rust	Mildew
Fielder	0	33	VS	S	R?	MR
Urquie	+2	32	MS	VS	VS	S
Dirkwin	0	33	R	S	R	R
Owens	−1	32	R	S	R	S
Waverly	+1	31	R-MR	R-MR	Seg	S
WS 1	−1	33	R-MR	R-MR	S?	R
WS 13	+7	25	S	R?	S?	?
WS4120	−1	28	RMR	MR	R?	?
WA6831	0	29	R	R	R	S

Table 3. 1983 Data New SWS Wheats (TW), Ave. 3 Expts. ea. Loc.

Accession	R.S.	Pullman	Lind
WA6831	113(63)	89(58)	42(60)
WA6916	121(64)	83(61)	40(61)
WA6917	124(65)	91(61)	41(61)
WA6918	125(61)	80(61)	43(60)
WA6919	129(64)	86(61)	42(61)
WA6920	130(65)	91(60)	42(61)
WA7073	131(65)	88(61)	42(62)
WA7074	122(65)	85(61)	41(62)
Waverly	106(63)	81(57)	42(60)

Table 4. 1983 Data SWS Wheats

	Heading/Disease, Pullman			
Accession	Heading Date	Stripe Rust	Leaf Rust	Stem Rust
WA6831	0	R	RMR	R
WA6916	−2	RMR	R	Seg
WA6917	0	MR	R	S
WA6918	−2	MR	R	Seg
WA6919	−1	MS	R	Seg
WA6920	0	MR	R	Seg
WA7073	−1	R	R	MS
WA7074	0	RMR	R	Seg
Waverly	0	RMR	R	MR

Table 5. Hessian Fly Resistant SWS Lines

		Yields (TW)			Head. Date/Disease (Pull.)		
Trial	Entry	R.S.	P	L	HD	Stripe Rust	Leaf Rust
X69	HF50	135(63)	83(60)	–	−1	RMR	R
	HF64	131(63)	84(59)	–	0	RMR	R
	Waverly	128(63)	85(58)	–	0	RMR	RMR
X52	HF37	113(65)	69(63)	40(64)	+2	R	R
	HF54	112(65)	72(60)	44(62)	−1	R	R
	HF55	113(63)	75(59)	44(61)	+2	MR	R
	Waverly	101(64)	79(58)	43(61)	0	RMR	RMR

Hard Red Spring Wheats

In 1983 more than one-half of all new HRS crosses involved H. fly resistance in 1 parent. Major emphasis has been on increasing the protein production capacity of these wheats, utilizing a wide range of exotic germ plasm sources which can also be expected to contribute favorably toward yield advancement in these wheats. New MSFRS populations were developed, with the second cycle initiated in 1982. Reselections from high protein WA 6823, WA 6824 and WA 6825 grown in New Zealand and increased at Royal Slope were shown to produce high yields of high protein grain under irrigation. The best lines were placed in state and Tri State Regional trials. Some results from 1983 trials of public and private varieties and advanced HRS selections are shown in Tables 6 and 7. Table 8 shows 1983 data from a trial of high protein HRS wheats.

1984-5 Objectives

(1) Initiate a head progeny reselection program under relative isolation to purify lines currently in Western Regional nurseries, aiming at more uniform seed stocks from which pre-breeder plants can be selected. (2) Evaluate advanced lines of SWS and HRS wheats in replicated trials at Pullman, Lind and Royal Slope, and at Cunningham and Harrington; select materials for regional trials; expand selection and yield tests on H. fly resistant SWS wheats. (3) Conduct facultative wheat screening trials at Pullman. (4) Consolidate advances in data management, improve efficiency of operations, accuracy of data, and access to analyses. (5) Continue MSFRS breeding populations in SWS and HRS wheats, and screen subpopulations for H. fly resistance and for winter survival. Begin sampling MSFRS populations for evaluation. (6) Continue modified pedigree breeding via crosses to improve the base of breeding materials with resistances to h. fly, stripe rust, leaf rust and mildew; evaluate 1983 crosses and select F_2, F_3 and F_4 materials for generation advancement and F_5 line increases for preliminary yield trials.

Table 6. HRS Commercial Variety Nursery Yields (TW)

Entry/Loc	R.S.	P.	H.	L.
Wared	113(64)	82(61)	55(63)	43(62)
Borah	114(64)	75(60)	50(63)	41(62)
Wampum	129(65)	86(61)	62(62)	42(61)
McKay	125(64)	87(61)	58(63)	41(63)
NK751	123(65)	93(62)	44(63)	40(62)
WS503	112(64)	83(61)	52(63)	42(62)
Yecora Rojo	109(64)	65(61)	41(64)	33(61)
WA7075	117(63)	87(60)	52(63)	40(61)
WA7076	103(65)	94(62)	51(64)	41(63)

Table 7. HRS Commercial Variety Nursery Suppl. Data

Entry	Heading (Wampum)	Pl. Ht(P)	Stripe Rust	Leaf Rust	Stem Rust	Mildew
Wared	0	32	MR	R	R	R
Borah	−6	29	MR	S	R	R
Wampum	0	39	R	R	S?	R
McKay	−3	30	R	R	R	R
NK751	−5	27	R	R	R	R
WS503	−4	31	R	S	?	?
Yecora Rojo	−7	23	S	R	R?	R?
WA7075	−2	32	R	R	R?	R?
WA7076	−2	32	R	R	R?	R?

Table 8. 1983 Data High Protein HRS Wheats

Acc.	Yield (Protein %)	
Location	R.S.	Lind (1 rep)
Wampum	119(12.7)	36(12.4)
CI17689/Wared HP4	121(14.0)	34(13.6)
CI17689/Wared HP8	116(14.2)	32(14.0)
V761-28-J4B2 HP28	123(14.0)	31(15.0)

BARLEY BREEDING AND TESTING IN WASHINGTON

S. E. Ullrich, K. J. Morrison, C. E. Muir, R. A. Nilan, P. E. Reisenauer, and D. A. Deerkop

Production

Barley production in 1983 in Washington was approximately 1.3 million tons (54.4 million bushels) from 850,000 acres. The state average yield was about 1.5 tons/acre (64 bushels/acre). Washington was the fourth largest barley producing state in the U.S. Planting projections for Washington for 1984 indicate that this will be the fourth year in a row of 800,000 plus acres of barley.

Objectives

The overall objective of the barley improvement program in the state of Washington is the development of high yielding, stiff-strawed agronomically acceptable varieties that are adapted to the different barley producing areas of Washington and that have superior quality. When winter grown, they must have winterhardiness superior to the current winter barley varieties. This objective includes the development of "multipurpose" varieties that will be the highest yielding varieties available. Spring varieties, whether 2-row or 6-row will have quality that will meet malting industry standards when grown under suitable conditions and they should be superior in feed quality. Thus they will meet all market demands for barley grown in the state.

The program involves the development of winter and spring, 2-row and 6-row varieties at Pullman with selection and testing at Lind (dryland), Harrington (winterhardiness), and Royal Slope (irrigated). Other major test sites are at Walla Walla, Dayton and Pomeroy. Vancouver, Puyallup, Mount Vernon, Dusty, Lamont, Cunningham, Deep Creek, Reardan, Bickleton, Mayview, Anatone, St. John, Uniontown, Fairfield, Farmington, and Wilbur are additional test locations.

Results

The varieties developed within WSU's barley breeding program are described in the front of the brochure under recommended barley varieties for the state of Washington. Representative results of the performance of these varieties in tests are summarized in the tables below. These tables also include some advanced selections which will be discussed below and other commercial varieties.

2-row Spring

Andre is a new 2-row spring barley released last year. Andre is recommended for malting and brewing and is superior to Steptoe in nutritional quality. Long-term averages establish Andre as having higher yields than Vanguard, Klages, Kimberly, Lud and Advance and approaching Steptoe (Table 3). Andre has a high test weight, is plump and is equivalent to Klages in malting quality. Certified seed is being produced in 1984.

Other 2-rows showing promise in advanced testing include the lines 8908-89, 8892-78, and 8771-78 (Table 2).

6-row Spring

Advance, WSU's most recent 6-row release was planted on about 10% of Washington's barley acreage in 1983. Its agronomic characteristics are described in the front of this brochure under recommended barley varieties for Washington. Advance is a designated malting barley and can be marketed as such if industry standards of quality are met by the grower. Advance has been proven to be superior to Steptoe and equal to the best 2-rows in nutritional quality especially due to its protein characteristics. Steptoe is still the leading variety in Washington. It was planted on 74% of Washington's barley acreage in 1983. Each of the other varieties grown in 1983 was planted on 3% or less of the barley acreage. Several newer 6-row selections are showing promise in advanced testing, especially 14583-77, 8542-78, and 8543-78 (Tables 2 and 3). New 6-rows should have high yield and good quality and have plumper kernels than those of Advance. A major drawback of Advance is small kernel size. The relative performance of several commercial varieties available in the state is presented in Table 4.

Winter Barley

The 1983-84 winter was relatively mild throughout the state which allowed for reasonably good winter barley survival. Several winter barley lines, particularly 6-row types, have yielded well over the past 3 years, including the semi-dwarf 2905-75. This line is quite short and lodging resistant and has good yield potential, but the test weight tends to be low. WA2905-75 is being proposed for release. The yield potential for winter barley is very good, but winterhardiness is a major limiting factor.

Table 1. Agronomic Performance of Andre, 20 Location Years, 1979-83, Pullman, Pomeroy, Dayton, Walla Walla

Cultivar	Yield bu/a	Yield % Steptoe	Test Wt. lb/bu	Plump* %	Plant wt* in	Lodging %
Andre	82	101	53	89	36	11
Vanguard	70	86	53	85	36	13
Advance	76	94	49	80	33	6
Steptoe	81	100	49	93	37	17

*Pullman 5 yr. average only.

Table 2. Agronomic performance of selected spring 2-row varieties and lines averaged over 4 or 3 years at Pullman, Pomeroy, Dayton and Walla Walla.

	Yield							
	80-83	81-83			13 Loc. Yrs.		Pu 80-83	
Selection	Pullman	Po	D	WW	Ave.	Steptoe	TW	Plump
	bu/a					%	lb/bu	%
2-row								
Andre	95	74	57	66	75	103	55	89
8892-78	103	76	56	57	75	103	54	90
8771-78	100	73	61	64	76	104	54	94
8908-78	99	73	59	68	77	105	54	92
Vanguard	92	64	46	46	64	88	54	86
Clark	89	63	49	57	66	90	55	94
Klages	87	68	49	58	67	92	54	89
6-row								
14583-77	111	57	51	56	72	97	52	90
8543-78	111	62	44	59	72	97	50	78
8542-78	104	59	49	56	70	95	51	88
Advance	100	63	45	48	67	91	50	82
Steptoe	102	63	58	63	73	100	50	93

Table 3. Spring Barley Extension Nurseries—Yield (bu/a) 1983.

Variety	Lamont	Dusty	St. John	Reardan	Deep Creek	Fairfield	Asotin
14583-77	59	58	105	77	113	85	75
Andre	61	63	67	84	96	84	68
Advance	53	45	75	79	94	75	61
Steptoe	59	56	85	90	116	89	75
	Goldendale	Bickleton	Uniontown	Farmington	Mayview	Wilbur	Davenport
14583-77	54	55	59	88	65	109	36
Andre	59	58	53	66	67	110	29
Advance	54	69	52	86	61	75	25
Steptoe	47	70	62	76	80	117	28
	14 Loc. Avg.	% Steptoe					
14583-77	74	97					
Andre	69	91					
Advance	65	86					
Steptoe	76	100					

Table 4. Feed Barley Yields Pullman and Royal Slope, 1982 and 1983.

	Steptoe	Columbia	Kombar	8359	10544	Advance	Gus	WB-501	Gustoe
					bu/a				
Mean	124	123	122	118	104	100	99	98	91
Pull.	108	102	101	102	99	88	89	77	86
R. S.	141	144	144	134	109	112	109	120	97

Table 5. Agronomic performance of WA2905-75 and checks, 6 year averages, 1977-83.

Variety	Yield					Test Wt.
	bu/a					-lb/bu
	Pull.	Pom.	Day.	W.W.	24 Loc. Yrs.	
2905-75	123	92	100	110	106	46
Boyer	105	82	87	104	95	47
Kamiak	108	80	85	95	92	47

Table 6. Winter barley extension nursery 4 year yield (bu/a) averages (1980, 81, 82, 83).

Variety	May-view	Dusty	Union-town	Asotin	Deep Creek	Reardan	Farmington	Golden-dale
WA2905-75	112	83	117	69	101	93	87	108
Kamiak	88	74	90	61	79	87	79	96
Boyer	72	74	105	65	98	100	81	87

Variety	Wilbur	Clyde	Lamont	Bickleton*	Fairfield*	4 yr Avg. 11 loc.	2 yr Avg. 13 loc.
WA2905-75	88	90	99	68	110	95	94
Kamiak	73	75	77	58	77	80	68
Boyer	89	91	104	59	113	88	80

*3 year averages (1981, 82, 83) only.

SOIL FERTILITY MANAGEMENT FIELD TRIALS FOR WHEAT PRODUCTION

Fred Koehler, Marvin Fischer, and Emmett Field

There are 14 field experiments concerning soil fertility management for wheat production in 1984. These are widely distributed throughout the wheat producing area of eastern Washington from Asotin to Waterville. A number of these involve a no-till management system or a comparison of no-till with a conventional tillage system. The use of spring top dressing with nitrogen for winter wheat is being 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, and sources and methods of application of various kinds of fertilizers including micronutrients with a no-till system.

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.

In general, where moisture is limiting, no-till gives wheat yields which are as good or better than those obtained with conventional tillage. Exceptions to this are where there are special problems associated with no-till such as severe rodent damage or uncontrollable weed problems. 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. However, this was not true in 1980 and 1981 when precipitation was much greater than normal in late spring and early summer. Apparently this precipitation moved the nitrogen and sulfur into the root zone. 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.

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. In the winter of 1981-82 a new problem was encountered in the Colton area. An excellent stand of winter wheat was obtained in spring wheat stubble, but nearly all the wheat plants died during the winter for no explainable reason.

At one location near Davenport, no-till has been compared with conventional tillage for 6 years. If the one year of severe rodent damage on the no-till plots is excluded, the average yields of winter wheat were the same for the two systems. For spring wheat, the conventional tillage averaged about 5 bu/A more than the no-till system.

In 1980 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.

SOIL ACIDITY AND CROP PRODUCTION

Fred Koehler

Soils of this region are becoming more acid (soil pH is decreasing) for three main reasons:

1. Leaching of bases (calcium, magnesium, and potassium) from the soil.
2. Removal of these bases in crops.
3. The use of ammonium type nitrogen fertilizers.

The first two of these are extremely slow processes so the major cause increasing soil acidity in this region is the use of ammonium type nitrogen fertilizers. In the approximately 30 years of nitrogen fertilizer here, soil pH's have dropped about 1 unit.

Acid soils may cause reduced yields of crops but the pH at which yield reductions begin depends on many factors. Different crops respond differently to soil acidity and there are even large differences among varieties of a single crop in sensitivity to soil acidity. Legumes in general require a higher soil pH than do grass-type crops.

An experiment was established on Spillman Farm about 10 years ago to study the effect of soil acidification on crops. Soil on one third of the plots was acidified, one third was left at the natural pH and one third of the plots received lime. The soil pH's are approximately 5, 6, and 7 respectively. A wheat-pea rotation has been used. There has not been much effect of soil pH on yield. One year, the wheat yields were significantly higher on the limed plots than on the other two treatments.

There are many ways in which soil acidity may affect plant growth. As soils become more acid, the amount of soluble aluminum increases and aluminum is toxic to plants. 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 pH than topsoils and the acidification from the use of ammonium type nitrogen fertilizers usually affects only the tilled layer of soil.

In general, natural soil pH's increase with decreasing precipitation. Therefore problems associated with soil acidity should occur first in the highest precipitation areas.

WHEAT VARIETY TOLERANCE TO CHLORSULFURON

R. E. Whitesides, D. G. Swan, and T. L. Nagle

Three varieties of soft white winter wheat, Daws, Luke, and Stephens, were planted in the fall of 1981 on a silt loam soil, pH 5.9 and 2.7% organic matter, in Whitman County, Washington. Herbicides were applied to four replications using a compressed air bicycle or backpack plot sprayer depending upon the wheat height. Applications were made when the wheat had 1-3 leaves, 4-8 tillers, and when the grain was in the soft dough stage.

Wheat tolerance to chlorsulfuron (0.016 lb ai/A) was evaluated against the "standard" wheat herbicides 2,4-D amine (0.75 lb ae/A), MCPA amine (0.75 lb ae/A), bromoxynil (0.38 lb/A), and bromoxynil + MCPA (0.38 + 0.38 lb/A). No visible differences could be seen among treatments in any variety at heading. However, application of 2,4-D at the 1 to 3 leaf stage caused a reduction in wheat height prior to heading. At harvest no yield differences between treatments were measured. Chlorsulfuron, applied at 0.016 lb/A, was not different from the untreated control or from any treatment on any variety at harvest. Varietal tolerance to chlorsulfuron was equal to wheat tolerance of many commercial herbicides used for broadleaf weed control in wheat, based on yield data from wheat varieties tested, and was not different from the untreated control.

Four varieties of soft white winter wheat, Daws, Hill, Lewjain, and Stephens, were planted in the fall of 1982 at the WSU Spillman Research Farm. The soil was a Palouse silt loam, pH 5.1 and 3.0% organic matter. Herbicides were applied when wheat had 2-3 leaves, 3-5 tillers, and 4 nodes. All herbicide applications were made with a bicycle-wheel plot sprayer or a compressed air backpack plot sprayer.

Herbicides tested were the same as the 1981 study (listed above); however, the formulation of 2,4-D and MCPA used in 1982 was the low volatile ester instead of amine. Experimental herbicide rates were also held constant. As with the earlier study, no visible symptoms were easily detectable on any variety at heading time. Application of 2,4-D LVE, and MCPA LVE at the 2-3 leaf and the 4-node stage of growth reduced wheat yield in Hill, Lewjain, and Stephens. Daws wheat appears to have the most tolerance at all growth stages to the herbicides tested. Application when the wheat was tillering did not reduce yield. The most exciting treatment, however, is chlorsulfuron applied at 0.016 lb ai/A which shows good tolerance on all varieties at all growth stages evaluated.

JOINTED GOATGRASS RESEARCH – 1975-1983

Dean G. Swan

Chemicals:

- Diuron
- Terbutryn
- PPG-135
- Metribuzin
- Atrazine
- Amitrole-T
- Oryzalin
- Trifluralin
- Profluralin
- Dinitramine
- Paraquat
- Glyphosate
- Triallate
- Diclofop
- MSMA
- Propham
- Chlorbromuron
- Cyanazine
- Alachlor
- Simazine
- Dalapon

Systems:

- Preplant broadcast and deep furrow seeded
- Preplant banded and deep furrow seeded
- Preplant incorporated
- Postplant incorporated
- Preemergence
- Postemergence broadcast
- Postemergence directed (shielded and non-shielded)
- Management:
  - Stale seedbed
  - Spring cropping
  - Chemical fallow
  - Mechanical fallow

Summary:

Twenty-one herbicides plus some numbered compounds have been tested for jointed goatgrass control in the cereal producing areas of eastern Washington. Most did not give satisfactory control of the weed, caused crop injury, or both.

Eight systems were used in testing these herbicides. Metribuzin, applied preplant at 0.5 lb/A a.i., followed by deep furrow seeding, was the most effective chemical. It gave an average 75% jointed goatgrass control and crop yields were highest 10 of 12 harvests. Crop safety is a problem on slopes or hillsides. If the treated soil moves into the wheat furrow, crop injury can occur.

Spring cropping gave an average 95% jointed goatgrass control but crop yields were highest only 2 of 13 harvests. The jointed goatgrass infested winter wheat outyielded the spring wheat or barley most of the time.

Directed or directed-shielded herbicide sprays gave 70% jointed goatgrass control with no crop injury.

INFLUENCE OF RUSSIAN THISTLE INTERFERENCE ON SPRING WHEAT

F. L. Young and W. A. Shull
USDA – Agricultural Research Service

Russian thistle is an annual broadleaf weed prevalent in the nonirrigated, low rainfall, wheat-producing areas of Washington, and is especially troublesome where spring grains are grown.

A 3-year study is being conducted at the Lind Dry Land Research Unit to determine the effect of Russian thistle density and duration of interference on spring wheat growth and development, yield, and yield parameters. Data from one year's research indicates that Russian thistle has the capability of being a severe competitor early in the growing season and that low populations of this weed may reduce crop yield.

MAYWEED (DOG FENNEL) INTERFERENCE IN WINTER WHEAT

F. L. Young, D. R. Gealy, W. A. Shull, and J. R. Pust
USDA – Agricultural Research Service

Mayweed (*Arthemis cotula*) is an annual, or winter annual, broadleaf weed prevalent in eastern Washington during cool, wet springs. It is somewhat resistant to applications of phenoxy herbicides and when allowed to grow undisturbed may severely compete with small grains for available light, nutrients, and moisture.

A study is being conducted at the Palouse Conservation Field Station to evaluate the effect of mayweed density and duration on winter wheat yield, yield parameters, and plant growth. Various densities of mayweed were established in plots planted to winter wheat to evaluate the minimum density of this weed required to reduce crop yield. Mayweed will also be allowed to interfere with winter wheat for various durations to determine the amount of time after weed emergence that mayweed may compete before a yield reduction occurs. This information can then be used to determine if the increased yield will offset the cost of weed control.

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

F. J. Muehlbauer, S. C. Spaeth, J. L. Coker, and R. W. Short
USDA – Agricultural Research Service

Dry pea and lentil 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:

Peas:

Root diseases of peas caused by a complex of several organisms are a major reason poor pea yields have been common to the area. Most of our efforts the past few years 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 and adaptability. Rates of water uptake in germinating seeds may influence susceptibility to root rots. Lines are being tested for differences in uptake rates to determine whether this trait can be used in pea improvement. Quality tests for resistance to seed bleaching and for adaptability to reconstitution are also conducted. New methods have been developed to accurately measure traits which influence resistance to bleaching. These will improve efficiency of breeding efforts. Dry pea cultivars that have been 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. Alaska 81 has resistance to *Fusarium* wilt race 1 and is tolerant to pea root rot.

'Garfield' is resistant to *Fusarium* wilt race 1, is larger seeded, and has a longer vine habit when compared with most Alaska strains. The increased plant height improves harvesting ease, especially on ridges where poor vine growth has been a problem. Garfield does not differ from Alaska in resistance to seed bleaching, powdery mildew, or mechanical damage resistance. 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 has yielded nearly 45% more than other small-sieve types. Other major improvements of Tracer over common, small-sieve Alaska strains include more uniform seed size, shape, and color; greater plant height; a lower 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.

Lines with pea seed weevil-resistant parentage that showed resistance to *Fusarium* wilt race 1 are being evaluated in cooperation with the University of Idaho in 1983 for resistance to the insect. Hopefully, agronomically acceptable lines can be identified and used as a control measure for the insect or to effectively reduce the percentage of infestation. One line (WA813768) has been identified as being highly resistant to pea weevil and is very close to a dry edible type. The line will be released as germplasm and used in the crossing program.

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.

Lentils:

Current objectives in lentil breeding are toward developing an early maturing 'Laird' type. Laird is a large-seeded non-mottled variety developed for use in Canada; however, Laird is somewhat late maturing and lower yielding than 'Chilean 78' when grown in the Palouse. While Laird's total biomass production is large, its seed production falls behind. Earlier maturing Laird types are now being increased for possible release pending performance in yield and quality tests. Studies are being started to determine whether seed production can be stabilized relative to biomass production in order to ensure efficient use of limited resources. Cultivars developed are as follows:

'Brewer' (LC711981) was the highest yielding lentil selection in yield trials over the past three years. The selection averaged about 300 pounds per acre more than Chilean and was larger seeded. Brewer was released and should be available to growers in 1985. Brewer is earlier to flower and mature and matures more evenly.

'Redchief,' a selection released in 1978 has shown a consistent yield advantage over Chilean. Redchief has red cotyledons as opposed to yellow for the commonly grown Chilean.

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.

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, based on 1980-1983 results, very favorable yields can be 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 which include (1) seeding rates-row spacing, (2) seed treatments, and (3) *Rhizobium* inoculation have been completed. All indications are that chickpeas can be developed as a successful crop for the Palouse. 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. Less than 20% of the chickpea production in India, estimated at 22 million acres, are Kabuli types. Promising Kabuli lines being tested include the unifoliate types (CP-8, Surutato 77) and the more common types (U-5 and ILC517). Promising Desi varieties include C235, ICC 4, and PI273879. Desi types appear to be well adapted to the Palouse environment and they appear to be easier to produce when compared to Kabuli types. Desis are also earlier to mature.

BENEFITS OF LEGUMES IN ROTATION WITH CEREALS

D. F. Bezdicek, C. Root, R. Turco, E. Kirby, R. I. Papendick
L. F. Elliott, J. Hammel, and R. Mahler

Recent projections on the future cost of nitrogen fertilizers and the current set-aside programs have reemphasized the need for legumes in rotation with cereals. Our continual battle with soil erosion can only be served through reevaluation of our cropping systems in view of the current options available in tillage management, and through the introduction of alternate legumes. Some specific aspects of our programs are as follows:

N Fixation by Legumes and N Budgets

Only a portion of the total plant legume N is taken from the air fixed in the nodules. The remaining comes from the soil. To do an N budget for a legume crop, the following must be determined.

1. Estimate of N fixed by the plant

2. Total N removed in the seed at harvest

For most seed legumes where the seed is harvested, more N is taken off than what is fixed by the plant which results in a net negative balance. In other words, more N is removed by the legume than what is provided by N fixation. In 1981 and 1982, we found that available soil N reduced the amount of N fixed in chickpeas. Under low soil N, chickpeas fixed over 140 lbs. per acre, whereas less than 10 lbs. per acre was fixed at one high soil-N site. We would expect the same trends for peas. These results point out the need for careful management of N on previous crops in rotation.

The Effect of Rotation

The benefits of rotations have been known throughout history. However, these benefits are now being reevaluated in terms of newer crop varieties, different tillage practices and equipment and higher yield expectations than thirty years ago. We are looking at the cereal yield response following a number of seed legumes (peas, lentils, chickpeas) and forage legumes (medics and clovers) managed as seed crops and green manure. The wheat production response to these legumes is being evaluated in terms of fertilizer nitrogen equivalent or the equivalent amount of fertilizer nitrogen saved by using the legume in rotation.

Only part of this response is due to the nitrogen contribution from the legume. Response from legumes in rotation (especially several years of forage) may also be due to breaking up disease and pest cycles, improved soil structure and tilth and to increased soil organic matter.

Effect of Tillage and Type of Legume on Response to Cereals in Rotation

Some government programs require that the legume be killed or turned under after a certain date. Previous experience with legume take-out by moldboard plowing was very erosive. We are looking at the beneficial effect of various legumes (peas, fababeans, chickpeas, sweetclover, medic) as potential green manure crops under three management tillage systems:

1. Moldboard plowing. Plant winter wheat with conventional tillage.

2. Chemical kill. Residue left on surface; winter wheat will be no-till planted into this residue.

3. Shallow tillage. Plant winter wheat with conventional tillage.

Three rotational systems will be superimposed on these tillage systems. These include (1) winter wheat-grain legume winter wheat; (2) spring wheat (interplant red clover)-red clover, green manure-winter wheat (3) winter wheat-Austrian winter pea, green manure-winter wheat. The ultimate response to the winter wheat will be evaluated in 1986.

Our studies will determine how the tillage practice will influence the availability of legume N to the following winter wheat crop and the potential contribution from the various legumes studied. We will also look at soil water depletion of various legumes planted in rotation with winter wheat.

Evaluation of Methods to Estimate N Fixation in Legumes

We have very few options as to what methods to use in estimating the amount of N fixed by a legume. If we measure the N in the legume plant, we have no way of knowing what proportion came from the air or from the soil. Some techniques we are looking at are:

1. Difference method. Measure total N difference between nodulated and non-nodulated plants. Useful only for legumes that are not nodulated by rhizobia in the soil. Not useful for peas and lentils.
2. ^{15}N methods, using an isotope of regular N. Useful for all legumes, but expensive. Cost of fertilizer ^{15}N is about $25,000 per pound. We use it very carefully.
3. The acetylene technique. Based on an enzyme assay using regular welding gas. This technique is inexpensive, but requires frequent sampling and is subject to errors.

Residue Manipulation for Enhanced N Fixation

Because of our results showing a reduction in legume N fixation with high residual soil N, we are exploring the possibility of increasing N fixation by reduction of N rates applied to wheat in rotation and by fall addition of wheat residue to plots that will be planted to peas the following year. We are looking at ways to facilitate planting of no-till wheat into previous wheat ground (residue removed for this purpose) and to "tie-up" the soil N during the pea growing season from the wheat residue removed.

CROP RESIDUE DECOMPOSITION

D. E. Stott, L. F. Elliott, G. S. Campbell, R. I. Papendick, and V. L. Cochran
USDA—Agricultural Research Service

Knowledge of crop residue decomposition has become necessary as conservation tillage systems come into practice. Surface-managed crop residues can cause several problems, such as seed placement and crop vigor. Other concerns addressed here include rate of plant residue decomposition and fertilizer use efficiency.

With surface-managed residues, the zone of maximum microbial activity is very close to the soil surface. Our work has shown that banding fertilizer one or two inches beneath the soil surface will avoid extensive microbial nutrient tie-up.

We feel it is important to know the decomposition rate of surface-managed crop residue and how the residue decomposes. One would think surface residues would decompose much slower than buried residues because of moisture and temperature relationships. However, observations indicate that surface residues in no-till seedings disappear fairly rapidly and there are few viable residues on the soil surface at harvest. Field and laboratory studies (including complete environmental measurement) are showing surface residues decompose more rapidly than expected. The reasons appear to be that more decomposition occurs at low temperatures and low amounts of water than expected from previous research data.

These studies will provide information for best crop residue management practices to prevent erosion, to increase crop growth, and to allow optimum fertilizer use.

RUNOFF AND EROSION PREDICTION AND CONTROL

D. K. McCool, K. E. Saxton, R. I. Papendick, and R. W. Van Klaveren

USDA – Agricultural Research Service

Erosion Prediction:

Frozen and thawing soils are an important element in runoff and erosion from non-irrigated cropland of the Pacific Northwest. Measurement of frost depth and extent is important to verification of erosion models. A network of thermometers and frost depth gauges has been installed with cooperators in eastern Washington and northern Idaho. Data from the winter of 1983/84 illustrate the range of soil freezing conditions encountered across eastern Washington and the modifying influence of snow cover. Coldest temperatures of the winter were recorded in December, but maximum frost depths were not recorded until mid to late January, mostly because of deeper snow cover in December. Frost depths on January 24 ranged from 2.5 inches near Waterville, where snow was quite deep, to 25 inches near Marshall, where snow cover was nil.

Effect of Crop Management on Runoff and Erosion

Studies at the Palouse Conservation Field Station indicate the significant impact on runoff and erosion of crop rotation and management. During the winter of 1983/84, winter wheat following summer fallow yielded 3.2 inches of runoff and 8.4 tons per acre of soil loss; winter wheat following peas yielded 2.0 inches of runoff and 1.3 tons per acre of soil loss; whereas winter wheat following small grain yielded 1.4 inches of runoff and 0.25 tons per acre of soil loss.

CONSERVATION TILLAGE

Keith E. Saxton

USDA – Agricultural Research Service

Slot-Mulch Tillage for Conservation

Slot-mulch tillage developed to enhance infiltration and manage residue continues to show promise on research plots and will be field tested by farmers this fall and winter. Measurements during the past winter of 1983-84 showed virtually no run-off from slot-mulched plots compared to considerable runoff and erosion from those conventionally tilled.

A machinery company has constructed a field machine to perform slot-mulch tillage and will be working in our area August and September of this year to install a number of field tests. The machine will pick up any windrowed residues, make a 10-12 inch deep slot, and compact the residues into the slot with compression belts. The practice will work best where small grain or heavy pea residues can be slotted in with no additional tillage until spring to avoid covering the mulched slots. The surface remains relatively smooth and fall or spring direct seeding can readily be done since most of the residues can be placed in the slot. The best residue method will be to just drop the straw and chaff directly behind the combine. Or swathers or rakes could be used as needed.

If you would like to try 50-100 acres on your farm, please contact Mr. Ralph Sesker, Rotary Corrugator Co., Route 3, Box 122, Ontario, Oregon (503-889-6266). They will furnish the tractor, machine, and operator. Conservation cost-sharing is available in both Washington and Idaho.

Paraplow as a New Conservation Tillage Tool

The Paraplow manufactured by Howard is a slant-legged chisel plow developed and used successfully in England. It produces significant soil fracturing to a working depth of 14-16 inches while leaving the soil surface quite level and virtually no disturbance to standing stubble. One of the first units imported to the U.S. is being tested at the Palouse Conservation Field Station.

The Paraplow shows significant promise as a conservation tillage tool to enhance water infiltration while maintaining good surface residues. Experiments are underway to test the effectiveness as a fall tillage in cereal grain stubble, after peas for winter-wheat recrop, and several other situations. First-year trials have shown that it does indeed aid infiltration and reduce runoff and erosion. Further tests will define where this implement will best fit into our rotations and its effectiveness.

GRASS COMPARISONS FOR EROSION CONTROL

Clarence A. Kelley, Manager
Pullman Plant Materials Center
Soil Conservation Service, USDA

The Pullman Plant Materials Center has been conducting a series of drought tolerant grass evaluation studies at the Lind Dry Land Research Unit and the Plant Introduction Station near Central Ferry, Washington to compare ground cover for erosion control. The 'broadcast' seedings began in the fall of 1977 and continued consecutively for three years—both spring and fall. The following tables reflect the percent ground cover by species and mixtures at the two locations in 1983.

Table 1. 1983 combined averages of three fall plantings. Percent ground cover provided by various species and mixtures at Lind.

Species	---- Fall Planting Dates ---- 1977	1978	1979	Combined Average
Nordan	48	43	64	52
Secar	85	44	81	70
P-1822 (thickspike wheatgrass)	51	39	94	61
Nordan and Covar	29/13	43/05	40/05	37/08
Nordan and Canbar	29/26	43/05	45/05	39/12
Secar and Covar	79/10	38/06	73/05	63/07
Secar and Canbar	78/10	36/05	74/04	63/06

Table 2. 1983 combined averages of three spring plantings. Percent ground cover provided by various species and mixtures at Lind.

Species	---- Spring Planting Dates ---- 1978	1979	1980	Combined Average
Nordan	45	36	48	43
Secar	76	24	51	50
P-1822 (thickspike wheatgrass)	64	43	88	65
Nordan and Covar	44/09	25/14	41/04	37/09
Nordan and Canbar	43/08	31/05	45/00	40/04
Secar and Covar	69/11	23/03	58/04	50/06
Secar and Canbar	74/06	25/01	54/01	51/03

Table 3. 1983 combined averages of six planting dates. Percent ground cover provided by various species and mixtures at Lind.

Species	Fall 1977	Spring 1978	Fall 1978	Spring 1979	Fall 1979	Spring 1980	Combined Average
	-------- Planting Dates --------						
Nordan	48	45	43	36	64	48	47
Secar	86	76	44	24	81	51	60
P-1822 (thickspike wheatgrass)	51	64	39	43	94	88	63
Nordan and Covar	39/13	44/09	43/05	25/14	40/05	41/04	39/08
Nordan and Canbar	29/26	43/08	43/05	31/05	45/05	45/00	39/08
Secar and Covar	79/10	69/11	38/06	23/03	73/05	58/04	57/07
Secar and Canbar	78/10	74/06	36/05	25/01	74/04	54/01	57/05

Table 4. 1983 combined averages of three fall plantings. Percent ground cover provided by various species and mixtures at Central Ferry.

Species	1977	1978	1979	Combined Average
	---- Fall Planting Dates ----			
Nordan	19	15	49	28
Secar	73	64	59	65
P-1822 (thickspike wheatgrass)	10	13	13	12
Nordan and Covar	9/76	19/38	24/45	17/53
Nordan and Canbar	3/16	24/05	34/03	20/08
Secar and Covar	49/48	43/38	44/41	45/42
Secar and Canbar	63/08	49/08	66/05	59/07

Table 5. 1983 combined averages of three spring plantings. Percent ground cover provided by various species and mixtures at Central Ferry.

Species	1978	1979	1980	Combined Average
	----Spring Planting Dates----			
Nordan	20	13	53	29
Secar	59	61	73	64
P-1822 (thickspike wheatgrass)	8	8	33	16
Nordan and Covar	15/54	5/74	34/41	18/56
Nordan and Canbar	20/08	19/T	46/05	28/04
Secar and Covar	36/45	19/63	46/33	34/47
Secar and Canbar	53/05	59/14	79/05	64/08

Table 6. 1983 combined averages of six planting dates. Percent ground cover provided by various species and mixtures at Central Ferry.

	Planting Dates						
Species	Fall 1977	Spring 1978	Fall 1978	Spring 1979	Fall 1979	Spring 1980	Combined Average
Nordan	19	20	15	13	49	53	28
Secar	73	59	64	61	59	73	65
P-1822 (thickspike wheatgrass)	10	8	13	8	13	33	14
Nordan and Covar	9/76	17/54	19/38	5/74	24/45	34/41	18/55
Nordan and Canbar	3/16	20/08	24/05	19/T	34/03	46/05	24/06
Secar and Covar	49/48	36/45	43/38	19/63	44/41	46/33	40/45
Secar and Canbar	63/08	53/05	49/08	59/04	66/05	79/05	62/08

TREES AND SHRUBS FOR DRY LAND PLANTING

David M. Baumgartner and Rod Clausnitzer
WSU Cooperative Extension

For over 50 years, trees and shrubs have been tested at Lind for farm-home landscaping and windbreaks. Testing was started at Lind in 1928 by the Dry Land Research Unit and the Department of Forestry and Range Management at Washington State University. Plantings have been made periodically since then.

Many of the trees and shrubs currently growing at Lind were planted during the period 1946 through 1948. Concurrently, similar test plantings were made at Prosser and Pullman, Washington, and Morro, Oregon. Station Circular 450, "Adaptation Tests of Trees and Shrubs for the Intermountain Area of the Pacific Northwest," summarizes the results of these adaptation tests.

The planting at the Dry Land Research Unit provides an excellent opportunity to observe the adaptability and growth of non-irrigated dry plantings over a long period of time.

Specific guidelines for windbreaks in the Pacific Northwest are available in the Extension Publication "Trees Against the Wind" PNW Bulletin No. 5. "Windbreak, Forest and Christmas Trees: Where to Get Trees to Plant," Extension Bulletin 0790, provides information on sources of trees.

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PUBLICATIONS ON WHEAT, BARLEY, OATS, PEAS AND LENTILS AVAILABLE FROM WASHINGTON STATE UNIVERSITY

Dry Pea Production, EB0582
Growing Lentils In Washington, EB0590
Garfield and Tracer Alaska Type Peas, EB0699
Tekoa Lentil Culture, EC0375
Pea Leaf Weevil: Biology and Control, EM3477
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Blazer Spring Malting Barley, EB0679
Advance Barley, EB0720
Vanguard Barley, EC0385
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Morphology/Himalaya Barley, XT0055
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Luke Wheat, EC0378
Paha Wheat, EC0379
Sprague Wheat, EC0390
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Frost Damage on Wheat, EC0398
Lewjain Winter Wheat, EB1168
Description and Culture of Chickpeas, EB1112
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Effect Seed Time/Spring Barley, XC0476
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Waverly Spring Wheat EB 1256
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Crew Winter Wheat EB 1212
Irrigated Spring Wheat Production in Washington EB 1111
Irrigated Winter Wheat Production in Washington EB 0916

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