WSU
FIELD DAYS

June 13, 1985
Dry Land Research Unit, Lind

June 27, 1985
Palouse Conservation Station
Field Day, Pullman

July 11, 1985
Spillman Farm, Pullman

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DEDICATION

George W. Bruehl

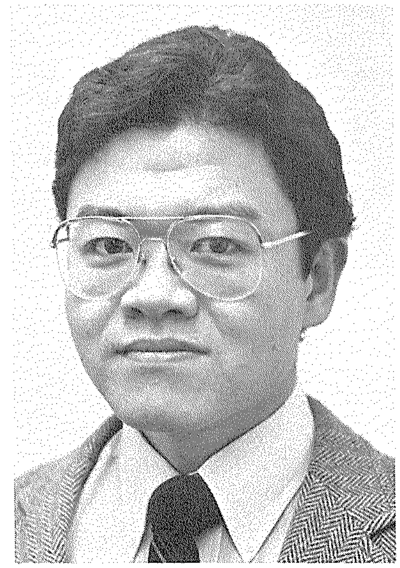
Dr. George W. Bruehl, Professor of Plant Pathology at Washington State University, retired September 30, 1984.

Professor Bruehl received a BSA degree (1941) from the University of Arkansas and a Ph.D. degree (1948) from the University of Wisconsin. He was a naval aviator during World War II.

Before coming to Washington State University Bill was a USDA researcher stationed at South Dakota State College, where he worked on pythium root rot, and at the University of Puerto Rico where he worked on sugar cane. He proved that pythium root rot of wheat and spring barley could cause serious damage if a nitrogen or phosphorus deficiency existed. He determined the vector specificity in barley yellow dwarf leading to release of the variety Cayuse, the leading oat cultivar in the Pacific Northwest. He also wrote a monograph on the barley yellow dwarf virus disease. He was the first to report on and identify *Cephalosporium* stripe disease in the United States and devised rotation control measures. He developed an effective control procedure for the serious foot rot of wheat caused by *Pseudocercosporella herpotrichoides* with the fungicide benomyl. He developed two – Sprague and John – snow mold resistant winter wheat varieties and identified species of *Typhula,* snow mold inciting organisms. He has published over 50 journal articles.

NEW FACULTY

William K. Pan



Dr. William Pan joined the faculty in December, 1984. He is a soil fertility management and mineral nutrition specialist.

Dr. Pan received his degrees from three universities. His Bachelor of Science was obtained from the University of Wisconsin at Madison in 1976 in the field of Biochemistry. He then went on to study at the University of Missouri-Columbia, where he received his Masters of Science in Agronomy in 1979. He received his Ph.D. degree in Soil Science from North Carolina State at Raleigh in 1983. His research included prolific corn genotypes, and nitrogen assimilation and use efficiency.

Mary (Kay) Walker Simmons

Dr. Mary (Kay) Walker Simmons is a Plant Physiologist/Biochemist working for the USDA Wheat Genetics, Quality, Physiology, and Disease Research Unit, headed by Dr. Robert Allan. Her current research deals with the role of plant hormones in preharvest sprouting of wheat. Dr. Simmons received her B.S. from Catholic University of America and her Ph.D. in Biochemistry from UCLA. She worked on post doctorate research at the Institute of Biological Chemistry here at Washington State University before joining us in October.

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 sixty years this station has followed this policy of studying the problems associated with the 8 to 12 inch rainfall area.

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

The present facilities include a small elevator that was constructed in 1937 for grain storage. A modern office and attached greenhouse were built in 1949 after the old office quarters were burned. In 1960 a 40' x 80' metal shop was constructed with WSU general building funds. In 1964 an addition to the greenhouse was built with a Washington Wheat Commission grant of $12,000 to facilitate breeding for stripe rust resistance. In 1966 a new deep well was drilled testing over 430 gallons per minute. A pump and irrigation system were installed in 1967. The addition of a 12' x 60' trailer house, and improvements in 1966 and 1967 amounted to over $35,000 with more than $11,000 of this from Wheat Commission funds and the remainder from state funds. In 1983 a new seed processing and storage building was completed at a cost of $146,000. The Washington Wheat Commission contributed $80,000 toward the building with the remaining $66,000 coming from the Washington State Department of Agriculture Hay and Grain Fund. A machine storage building was completed in 1985 at a cost of $65,000 funded by the Washington Wheat Commission. The old machine storage built shortly after the station was established was removed this year.

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. ? Hatton Batum

Since 1916 an annual field day has been held to show farmers and interested businessmen the research on the station. This year marks the 68th 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

Month	Temperature °F. Max.	Temperature °F. Min.	Precipitation 1984	Precipitation 1985	Precipitation 64 yrs. av. (in)
January	34	22	.67	.40	1.02
February	42	24	.82	.40	.89
March	53	32	1.76	.81	.77
April	63	35	1.54	.18	.67
May	72	42	1.24		.79
June	83	45	.95		.86
July	90	52	.03		.25
August	90	50	T		.33
September	79	45	.82		.56
October	65	38	.36		.87
November	47	29	2.65		1.24
December	37	26	.77		1.30
			11.61		9.55

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, 1984-1985

Month	Monthly Avg. Temperature (F)		Precipitation				
	Max.	Min.	30-Yr. Avg.*	Monthly	Total Accum.	Deviation from Avg. Monthly	Deviation from Avg. Accum.
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
April	53.0	34.6	1.55	1.46	8.48	−0.09	+0.24
May	60.4	39.9	1.53	1.89	10.37	+0.36	+0.60
June	69.3	45.8	1.65	2.19	12.56	+0.54	+1.14
July	82.8	49.5	0.45	0.84	13.40	+0.39	+1.53
August	83.5	51.1	0.64	0.39	13.79	−0.25	+1.28
September	69.3	42.3	1.14	0.97	14.76	−0.17	+1.11
October	55.8	34.6	1.83	1.61	16.37	−0.22	+0.89
November	43.3	32.5	2.66	3.81	20.18	+1.15	+2.04
December	31.7	19.8	2.67	3.71	23.89	+1.04	+3.08
TOTAL	56.4	36.6	20.81		23.89		+3.08
1985							
January	27.4	14.6	2.79	0.49	0.49	−2.30	−2.30
February	33.3	19.0	2.06	1.60	2.09	−0.46	−2.76
March	45.9	28.6	1.84	1.64	3.73	−0.20	−2.96
April	60.0	37.2	1.55	0.88	4.61	−0.67	−3.63
TOTAL			8.24		4.61		−3.63
1985 CROP YEAR Sept. 1984 thru April 30, 1985			16.54		14.71		−1.83

*Thirty-year average for precipitation, 1941-1970

ADAPTED PUBLIC VARIETIES—WHEAT, OATS, BARLEY

AREA	WINTER WHEAT	SPRING WHEAT	OATS	SPRING BARLEY	WINTER BARLEY
EASTERN WASHINGTON 14 Inches or More Rainfall	Nugaines Daws Stephens Tres Hill 81 Lewjain Crew Dusty	Dirkwin Waverly Edwall Owens Penawawa	Cayuse Appaloosa	Steptoe Advance—malting Belford—hay only Andre—malting	Kamiak Boyer Showin
EASTERN WASHINGTON Less Than 14 Inches Rainfall	Wanser McCall Hatton Sprague Lewjain Batum Moro Tres Crew	Wampum Waverly Dirkwin Edwall Owens Penawawa		Steptoe	Kamiak
CENTRAL WASHINGTON Under Irrigation	Daws Stephens Hill 81 Lewjain Dusty	Wampum Waverly Dirkwin Owens Penawawa	Cayuse Appaloosa	Andre Klages Steptoe Belford—hay only	Boyer Hesk Showin
Snow Mold Areas	Sprague John				

WHEAT, BARLEY, AND OATS

Kenneth J. Morrison
Washington State University

Winter Wheat

Dusty

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

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

Tres

Tres is a soft white club winter wheat. It is a semidwarf with awnlet compact heads, white glumes and straw.

Tres has intermediate resistance to stripe rust, leaf rust and powdery mildew. Tres is moderately susceptible to strawbreaker foot rot. It is highly susceptible to flag smut, *Cephalosporium* stripe, and most races of the dwarf bunt.

Tres has high yield potential with a better yield record than other club wheats grown in the area.

Tres has heavier test weight than other club wheat varieties. It is less coldhardy than Tyee, and emerges more slowly than Moro or Paha. Tres has typical club wheat milling and flour qualities.

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

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.

John

John is a soft white winter wheat with white chaff. The straw height is about the same as Sprague, but is weaker than most other varieties but superior to Sprague. Yields are slightly higher than Sprague.

The emergence appears to be good. The snow mold resistance is comparable to Sprague. John has a slightly higher flour yield than Sprague; otherwise it is similar to Sprague in quality. Yields of John are comparable to Sprague.

It is similar to Sprague in stripe rust resistance, but is slightly less leaf rust-resistant.

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

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.

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.

Batum

Batum is a hard red winter wheat with a white chaff common head. Batum is a semidwarf with shorter straw than Wanser, Hatton or Westin, but the lodging resistance is better than the other hard red winter wheats. The variety emerges equal to Wanser or Hatton. The winterhardiness of the variety is slightly below the other hard red winter wheats. Yield of Batum has been slightly better than Hatton, Wanser or Westin.

It is susceptible to dwarf bunt, but is resistant to stripe rust and moderately resistant to leaf rust. The variety is susceptible to *Cercosporella* foot rot and snow mold. It has acceptable milling and baking quality, but the test weight is 1 lb less than Wanser.

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

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.

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.

Showin

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

Feeding trials indicate Showin is similar to Kamiak and Boyer in nutritional value.

Showin was developed by Washington State University.

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.

Monida

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

SOFT WHITE WINTER WHEAT IMPROVEMENT

C. J. Peterson Jr., S. J. Hayward, D. F. Moser, and P. S. Pearce

Washington wheat growers harvested 159 million bushels of wheat in 1984 for an average yield per acre of 61.5 bushels. Good growing conditions prevailed throughout most of Eastern Washington during the 1983-84 crop year. Stands and plant vigor were reduced in areas that lacked snow cover during the severely cold winter weather. *Cephalosporium* stripe and stripe rust were the major cereal diseases. *Cercosporella* foot rot, leaf rust, and stem rust also reduced grain yields in some parts of the Pacific Northwest.

Foundation seed of Dusty (PI486429, WA006912, VH074575) a soft white winter wheat will be available in the fall of 1985. It was selected in the F4 from the cross, Brevor/CI15923//Nugaines. Dusty is a high tillering, late maturing, semidwarf with medium spikes, awns, and white glumes. It is resistant to the local races of stripe rust and common bunt. Dusty has shown some tolerance to flag smut, leaf rust, snow mold, and *Cephalosporium* stripe. It is susceptible to dwarf bunt, stem rust, and *Cercosporella* foot rot. Emergence of Dusty is similar to that of Stephens but the straw is weaker and it may lodge under high production. Dusty produced an average of 69.9 bu/a of grain for 63 site/yrs of tests and it averaged 3.1, 1.6, and 7.3 bu/a more than Daws, Stephens and Nugaines, respectively. Dusty averaged 59.5 pounds per bushel for 69 site/yrs of tests and it averaged 0.8 lbs/bu less than Nugaines and 0.2 lbs/bu more than Daws. The winterhardiness of Dusty is similar to that of Nugaines. The milling and flour characteristics of Dusty are quite similar to that of Daws.

Two new semidwarf soft white winter wheats (WA007168 and WA007169) were entered in the 1984-85 Western Regional Winter Wheat Nursery. They were among the top producing lines in 1983-84 and appear to have wide adaptation. Both lines have good winterhardiness and some tolerance to *Cephalosporium* stripe.

Three lines selected from a bulk of WA006910 (Maris Huntsman/VH074521) expressed good resistance to *Cephalosporium* stripe. They averaged 91 bushels per acre in the early nursery at Pullman which was severely infected with *Cephalosporium* stripe. Stephens produced 22 bushels per acre in this same nursery. They are late maturing lines that have good stripe and leaf rust resistance. Unfortunately, the three lines are very susceptible to common bunt and they are equal to Stephens in winterhardiness.

Table 1 contains the average grain yield data (bushels per acre) for 9 winter wheat varieties grown at 5 locations in Washington during the past five years. The 1983-84 grain production of Stephens was reduced at Pomeroy by *Cephalosporium* stripe and by low temperatures at Ritzville. Lewjain and Daws had the highest grain production when the yields were averaged across all locations in 1983-84. Lewjain had the highest overall production. Table 2 contains the yield data for 1983-84 and the 5 year average for 8 soft white winter wheats grown at Pullman, Walla Walla, and Ritzville. Dusty produced the most grain at Pullman, Walla Walla, and overall in 1983-84. Dusty also had the highest yield when the data was averaged over the past five years. Daws produced the most grain at Ritzville in 1983-84. The five year average for Hill 81 was omitted because it has only been in the nursery for three years. Tres, a new club wheat, had the best overall bushel weight in 1983-84. This is the first time that a club wheat has had a higher bushel weight than the common wheats.

Table 3 contains agronomic and disease data on 10 soft white winter wheats. Tyee, a soft white winter club wheat, is susceptible to a new race of stripe rust that developed in 1984. Emergence of the semidwarf wheats continues to be a problem.

Table 1. Data (bu/a) on 9 Soft White Winter Wheats Grown in 5 locations in Washington For Five Years.

	1980	1981	1982	1983	1984	Avg.
Common Wheats						
Nugaines	62	53	80	74	72	68
Daws	66	62	87	84	94	79
Stephens	56	74	85	93	72	76
Lewjain	76	63	85	94	94	82
Dusty	69	72	75	89	88	79
Hill 81			87	87	89	
Club Wheats						
Tyee	66	59	84	79	83	74
Crew	65	58	83	82	88	75
Tres	70	70	82	79	82	77

Table 2. Yield (bu/a) and test weight (lb/bu) data on 8 winter wheats for 1983-84 and their 5 year average for yield.

	Pullman		Walla Walla		Ritzville		Average		Test Wt.
	83-84	5 yr	83-84	5 yr	83-84	5 yr	83-84	5 yr	Avg.
Common Wheats									
Daws	83	74	120	81	81	72	95	76	59.9
Lewjain	78	82	123	85	78	75	93	81	59.2
Stephens	82	79	131	88	29	61	81	76	58.8
Dusty	93	82	137	92	60	72	97	82	59.3
Hill 81	85		120		63		89		59.8
Club Wheats									
Tyee	84	77	119	81	78	71	94	76	57.5
Crew	89	77	113	84	74	68	92	76	58.9
Tres	84	84	118	90	71	67	91	80	60.5

Table 3. 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 Wheats									
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
Dusty	5	5	med-late	7	R	S	MS	MR	MS
Club Wheats									
Tyee	5	5	medium	5	MR	S	S	R	MS
Crew	6	5	medium	6	MR	S	I	MR	MS
Tres	6	5	medium	7	MR	S	MR	MR	MS

*1=poor - 10=excellent
**R=resistant, MR=moderately resistant, I=intermediate, 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 Selection

WA6820 (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. An attempt is being made to select for plants resistant to TCK.

Results

1984 crop: Winter injury and cereal diseases reduced the yields in all nurseries. Although most selections were not killed by the winter weather, they were injured and slow to recover in the spring. If the spring had not been unusually wet, many selections probably would not have recovered.

The most damaging diseases in the wheat summer fallow areas were stripe rust, barley yellow dwarf, and straw breaker foot rot. Leaf rust was severe late in the season, but probably caused little yield reduction. *Cephalosporium* stripe was prevalent in the Harrington nursery. Snow mold caused severe damage to susceptible selections in the Waterville nursery.

1985 crop: Winter damage is evident on only a few of the weakest selections in the nurseries. Downy brome is a problem in the Horse Heaven nursery. The Finley nursery, like many growers' fields, shows metribuzin damage. A spring frost (20°F.) on April 21 caused differential leaf killing among varieties in the Lind nursery. Some spring barley was killed to the ground, but very few plants were killed.

Table 1. Summary of agronomic characteristics of winter wheat varieties grown near Harrington in rod row nurseries, 1952-84.

Variety	Av. Test wt.	1984 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. years grown
Nugaines	61.6	50.0	42.2	137	19
Daws	60.2	61.3	46.1	142	11
Dusty	59.0	53.1	47.9	144	2
Luke	60.8	52.5	45.4	148	16
Lewjain	60.3	56.7	50.2	159	8
John	59.4	52.6	46.8	152	4
Stephens	59.9	44.9	46.0	142	11
Hill 81	60.7	53.8	53.9	158	3
Moro	59.0	60.9	42.4	138	19
Crew	59.1	64.1	56.4	168	7
Tyee	58.4	60.4	52.9	164	9
Tres	59.7	63.1	57.2	173	
Batum	59.5	51.7	52.2	153	3
Hatton	63.0	56.7	46.7	145	9
Kharkof	61.1	38.3	33.8	100	31

Table 2. Summary of agronomic characteristics of winter wheat varieties grown at Lind in rod row nurseries, 1952-84.

Variety	Av. Plant ht.	Av. Test wt.	1984 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. years grown
Nugaines	26	61.4	42.8	36.2	128	20
Daws	29	59.3	38.9	34.6	132	11
Dusty	26	60.6	43.9	32.5	216	2
Luke	26	59.7	37.4	32.9	125	16
Lewjain	27	59.3	41.0	32.3	137	8
John	28	60.2	42.6	32.7	126	4
Stephens	27	58.3	35.9	32.2	126	12
Hill 81	27	59.3	37.9	28.9	110	3
Moro	30	58.5	39.7	35.6	124	21
Crew	27	58.3	38.7	36.0	145	7
Tyee	27	58.4	41.0	33.3	117	9
Tres	28	60.3	44.2	38.7	146	5
Wanser	32	61.7	41.6	33.2	115	21
Hatton	31	64.0	41.7	32.6	133	9
Weston	34	61.7	41.8	32.4	130	7
Winridge	32	61.2	49.6	34.7	131	5
Batum	29	60.7	49.0	39.6	153	4
Kharkof	33	60.6	36.9	28.8	100	30

Table 3. Summary of agronomic characteristics of winter wheat varieties grown at Horse Heaven Hills in rod row nurseries, 1951-84.

Variety	1984 Yield bu/a	Yield % Kharkof	Av. Test wt.
Wanser	48.2	127	63.5
Hatton	46.9	123	64.5
Batum	53.9	142	60.6
Weston	48.9	129	63.8
Winridge	53.0	139	61.6
Kharkof	38.0	100	63.4

Table 4. Summary of agronomic characteristics of winter wheat varieties grown at Finley in rod row nurseries, 1984.

Variety	1984 Yield bu/a	Yield % Kharkof	Av. Test wt.
Wanser	35.8	107	63.8
Hatton	46.5	139	64.4
Batum	35.6	106	62.2
Weston	37.3	111	63.4
Winridge	33.0	99	62.5
Kharkof	33.5	100	63.0

Table 5. Summary of agronomic characteristics of winter wheat varieties grown at Connell in rod row nurseries, 1975-84.

Variety	Av. Test wt.	1984 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. years grown
Daws	60.8	62.3	40.5	132	7
Lewjain	62.0	74.0	50.4	146	2
John	61.5	69.6	47.6	138	2
Stephens	60.1	64.5	41.2	135	7
Tres	62.8	66.6	66.6	134	1
Wanser	62.6	54.7	36.4	115	8
Hatton	63.6	67.9	40.7	133	7
Weston	63.4	65.3	42.1	135	5
Winridge	61.7	68.3	48.2	140	2
Batum	60.8	71.9	51.2	148	2
Kharkof	61.7	49.4	31.7	100	8

Table 6. Summary of agronomic characteristics of winter wheat varieties grown near Waterville in rod row nurseries, 1952-1984.

Variety	Av. Test wt.	1984 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. years grown
Luke	61.1	49.2	47.6	150	12
Stephens	59.3	26.1	39.0	133	6
Lewjain	61.8	66.3	51.8	179	4
Sprague	60.9	61.0	47.1	149	9
John	61.7	60.9	50.1	173	4
Crew	60.4	18.5	40.5	126	3
Tyee	59.2	27.7	43.0	154	5
Tres	61.7	27.1	27.1	86	1
Wanser	62.0	15.0	38.0	112	16
Hatton	63.6	22.0	39.9	136	6
Weston	62.7	40.0	37.6	134	5
Winridge	61.8	46.6	41.0	141	4
Batum	60.9	28.5	42.1	145	4
Kharkof	61.2	31.4	33.3	100	25

PERFORMANCE OF MIXTURES OF FOUR SOFT WHITE WINTER WHEAT CULTIVARS

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

Yield comparisons were made on Daws (D), Stephens (S), Lewjain (L), and Nugaines (N) wheat cultivars and their 11 possible mixtures in 11 trials in 1983 and 1984. Among the 484 possible comparisons of the various mixtures to the cultivars, the yields of the mixtures were greater than, equal to, or less than the cultivars in 18, 69 and 13 percent of the comparisons, respectively. Across the four tests in 1983, Lewjain, Stephens, and mixtures DLS, DL, and DLN produced comparable ($P>0.05$) high mean yields. Across the seven trials in 1984, Lewjain, Daws, and mixtures DLS, DL, DLN, DS, LN, DN, and DLNS had comparable ($P>0.05$) high mean yields. For the 2 years across the 11 tests, Lewjain ranked the highest for yield; however, mixtures DL, DLS, and DLN had comparable yields.

Lewjain consistently yielded equal to or more than ($P<0.05$) the other three cultivars in each of the 11 trials. Daws, Nugaines, and Stephens yielded less than Lewjain in 6, 5 and 3 trials, respectively. They had comparable ($P>0.05$) yields with Lewjain in the remaining tests. Mixtures DLN, DLS, LNS, and DL each yielded less than ($P<0.05$) Lewjain in one trial and they had comparable ($P>0.05$) yields to it in the other 10 trials.

In 1983, the mixtures appeared to be less adapted to no-till than the cultivars. At a favorable no-till site, the mixture yields were enhanced by 17 percent vs. 33 percent for the cultivars while at an unfavorable no-till site, the mixture mean yields were reduced 13 percent vs. 3 percent for the cultivars. In the 1984 test, no-till reduced mean yields of cultivars and mixtures by 32 and 35 percent, respectively.

GENETIC STUDIES OF ENVIRONMENTAL STRESS TOLERANCE IN WHEAT

R. E. Allan, J. M. Poulos, P. Pearce, and L. Kruger

Crown Depth and Coldhardiness. Crown depth is related to coldhardiness among some of our soft white winter wheats. Daws, Nugaines, Stephens, and Cappelle rank in that order for both coldhardiness and for crown depth. Former research assistant, Jean M. Poulos, studied the inheritance of crown depth in several crosses both in the greenhouse and field. She developed effective non-destructive greenhouse tests for determining crown depth of wheat lines. Crown depth and the related trait of subcrown internode length had heritability values of moderate magnitude (29 to 48) based on the greenhouse method. Ms. Poulos found that when testing in the field crown depth was more reliable a measurement than subcrown internode length. In the greenhouse, both traits were equally reliable but subcrown internode length was easier to measure. Apparently few genes govern inheritance of crown depth and subcrown internode length in three crosses. The deep crown trait of Daws was controlled by two recessive genes which were epistatic to each other. Selection for crown depth or subcrown internode length should be delayed until the F_4 generation. Some traits such as plant height and coleoptile length correlate with crown depth and subcrown internode length but none of the traits could be used as a selection criterion to improve crown depth or subcrown internode length. Our next objective is to determine the precise genetic relationship between crown depth and coldhardiness.

Breeding White Wheat Resistant to Sprout Damage. In 1984, highly significant correlations were obtained between germination rate index and percent germination with alpha-amylase activity among F_5 progeny of the Brevor/Vakka cross. Germination rate index assesses the degree of post-harvest seed dormancy. Low alpha-amylase activity or resistance to sprouting is being derived from both Brevor and Vakka. The 1984 tests showed that there were six different phenotypic classes for germination rate index or post-harvest dormancy among progeny of the Brevor/Vakka cross. This suggests more than two genes control post-harvest seed dormancy. Brevor probably contributes at least two major genes for post-harvest seed dormancy in this cross. Vakka may not have any strong dormancy genes and its resistance to sprout damage or low amylase activity is achieved by some way other than seed dormancy. We were able to show that some progeny which have very low alpha-amylase activity also have strong seed dormancy but other lines equally low for alpha-amylase activity had almost no seed dormancy. We selected several lines that have maintained very low alpha-amylase activity in five tests over a 3 year period. Some have Brevor-like dormancy. We intermated several of these lines in 1984 to establish a recurrent selection program to obtain even higher resistance to sprout damage. These lines are in replicated tests in 1984 to determine their agronomic potential and to get enough seed to evaluate them for additional milling and flour quality tests.

DEVELOPING LINES WITH MULTIPLE DISEASE RESISTANCE

R. E. Allan, J. A. Pritchett, L. M. Little, D. Roberts, P. Pearce

The ARS-USDA plans to expand efforts on wheat germplasm enhancement and reduce research on variety development. An important part of germplasm enhancement which is often also called parent building and pre-breeding is to assemble combined resistances to several diseases in the same line or parent. None of our current soft white winter wheat varieties possess resistance to more than three of the six diseases shown in the table. This table lists 10 lines that appear to have promise for combined disease resistance. Five of the lines are classed as having intermediate, moderate resistance or resistant reactions to *cephalosporium* stripe, strawbreaker foot rot, common bunt, leaf rust, stripe rust, and stem rust. The sources of these resistances apparently represent a moderately wide genetic base. They derive disease resistance from various cultivated wheats and also from *T. ventricosum* and *Agropyron elongatum* which are wild relatives of wheat. A few of these lines have been placed in our advanced yield trials and may have potential to become varieties. All are being used as parents of new crossbred selections.

Table. Disease resistance ratings † of ten promising lines with combined disease resistance and five varieties 1984.

Line or Variety	Rust Stripe	Rust Leaf	Rust Stem	Ceph. Stripe	Straw-breaker	Common Bunt
Sel. 421/2*RDR	MR	MR	R	MR	R	R
Sel. 951/2*H81	R	R	R	S	MR	MR
Sel. 421/2*Tyee	R	R	R	S	I	I
Sel. 4/2*CH/AE/PN/2*OM	R	MR	R	MR	MR	MR
Sel. 41/WA6241	R	R	R	MR	MR	MR
Sel. 951/H81	R	R	R	I	R	MS
Sel. 421/RDR	R	R	R	MR	R	MR
Sel. 7142/SU92/OM/Tres	MR	MR	MR	MS	MS	MR
Sel. 4/2*CH/AE/2*OM	R-I	MR	R	MR	MR	R
Sel. 7142/SU92/OM/CH/AE	R	R	R	MS	MS	MR
Lewjain	R	S	S	MR	MS	R
Hill 81	R	MS	S	I	MS	MR
Daws	R	S	S	MS	MS	MR
Stephens	R	MR	S	VS	I	MS
Nugaines	I	S	S	I	S	MR

†R - resistant, MR - moderately resistant, I - intermediate, MS - moderately susceptible, S - susceptible, VS - very susceptible

IMPROVEMENT OF TWO-GENE SEMIDWARF SELECTIONS

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

Yield increases have been made among several two-gene (Rht_1Rht_1 Rht_2Rht_2) semidwarf lines after two cycles of recurrent selection. Based on results from eight trials conducted in 1982 to 1984, eight lines had mean yields across trials of 85 to 92 bu/a. Lewjain, Daws, and Stephens had means of 84, 81 and 81 bu/a, respectively. These two-gene semidwarfs exceeded ($P<0.05$) the yield of WA4303 by 11 to 21 percent. WA4303 is the source of the two semidwarf genes of these high yielding lines and it has generally demonstrated the highest yield potential among our older two-gene semidwarf lines. The main faults of these two-gene semidwarfs are low test weight, mediocre emergence, fair to poor milling score, and vulnerability to sprout damage. Lines with only moderate to intermediate resistance to stripe rust, leaf rust and stem rust have sustained severe damage under heavy disease levels. We are interested in two-gene semidwarfs because they have favorable harvest indexes, lodging resistance, short stubble and are adapted to irrigation and shallow soil environments.

CERCOSPORELLA FOOT ROT RESISTANCE

R. E. Allan, C. J. Peterson, J. A. Pritchett, L. M. Little, D. Roberts

Progress in variety development. We have made very good progress in developing wheats with high resistance to *cercosporella* foot rot. Tests on advanced lines have been conducted for 4 years and several lines have maintained average yields over that period of 95 to 112 bu/a (Table). In the same 4 year period, Nugaines, Daws and Stephens have averaged 62, 72 and 68 bu/a (Table). The seven lines shown in the Table sustained 4 year average yield reductions caused by foot rot which ranged from 1 to 5 percent whereas Stephens, Daws and Nugaines had losses of 15, 33 and 41 percent, respectively. All of the foot rot resistant lines derive their resistance from a weedy relative of wheat known as *Triticum ventricosum*. The pedigrees of these lines trace to the varieties Raeder, Barbee, Hyslop, Stephens and Hill 81. Some of the lines also have good resistance to *Cephalosporium* stripe and to leaf, stripe and stem rust. Line 8421 and 8417 performed exceptionally well in the 1984 regional soft white winter wheat nurseries and ranked second and third in average yield among 30 entries tested across 18 to 20 locations in the western region. Unfortunately the milling quality of Sel. 8417 is questionable so it will probably be dropped. If Sel. 8421 continues to perform well, we plan to recommend it for release probably by the fall of 1987.

Genetics of foot rot resistance. A genetic study was conducted on F_3, F_4, and F_5 offspring of a cross between the foot rot resistant Selection VPM1/Moissan and foot rot susceptible Selection 101 in order to determine exactly when in the breeding program we should begin to select for foot rot resistance. We also desired to determine the inheritance or heritability of foot rot lesion score. Selections were rated for their reactions to the foot rot fungus by counting the number of straws which had lesions. The severity of lesion was also rated. Selection for foot rot resistance can begin in the F_3 generation. The heritability of the trait was intermediate to high ranging from 53 to 82. This means that evaluation of foot rot resistance by means of the lesion rating method is functionally heritable and can be used as a selection trait early in the breeding program prior to yield testing. The disadvantages of the lesion rating method are high labor and slowness. Foot rot lesion rating was consistently and highly correlated with lodging, biological yield, grain yield and test weight among offspring of all three generations. The two most useful traits for predicting foot rot lesion rating

Table. Yields of seven strawbreaker foot rot resistant lines and three varieties inoculated with foot rot fungus.

Line or Variety	1981	1982	1983	1984	Aver.
	bu/a				
Sel. 421/2*RDR-8417	101 (0)	122 (5)	106 (0)	64 (6)	98 (3)
Sel. 421/2*RDR-8418	99 (0)	147 (5)	111 (0)	91 (2)	112 (2)
Sel. 951/2*H81-8419	104 (0)	135 (0)	138 (0)	49 (21)	107 (5)
Sel. 951/2*H81-8420	112 (0)	132 (6)	139 (0)	70 (5)	113 (3)
Sel. 951/2*H81-8421	94 (12)	129 (7)	137 (1)	65 (0)	106 (5)
Sel. 951/2*BBE-8424	82 (0)	146 (0)	104 (0)	93 (6)	106 (1)
Sel. 421/HYS/SPN-8422	104 (0)	122 (0)	118 (0)	35 (6)	95 (1)
Nugaines	17 (64)	113 (15)	66 (40)	51 (43)	62 (41)
Daws	34 (64)	116 (18)	61 (19)	75 (34)	72 (33)
Stephens	55 (45)	107 (13)	69 (3)	41 (0)	68 (15)

( ) indicates percent grain yield loss versus Benlate control plot.

were lodging and biological yield. Lodging and biological yield accurately predict foot rot lesion rating 39 and 27 percent of the time, respectively. No relationship was found between foot rot lesion rating with either winter survival or date of heading. This is good news and means resistance can be obtained for coldhardy lines in a wide range of heading dates. Visual rating of foot rot resistance prior to harvest gave moderately high correlations with foot rot lesion rating ranging from 0.40 to 0.67. However, simply observing lodging was a better prediction of foot rot resistance than this visual rating.

CONTROL OF STRIPE RUST, LEAF RUST AND STEM RUST OF WHEAT

Roland F. Line
USDA, Plant Pathology

General Characteristics. Three rusts (stripe rust, leaf rust, and stem rust) occur on wheat in the Pacific Northwest. Stripe rust appears as golden-yellow, long, narrow stripes on the leaf surface and glumes; leaf rust appears as small, red pustules on the leaf surface and leaf sheath; and stem rust appears as larger, red-brown, diamond-shaped pustules on the leaf surface and stems. Stripe rust and stem rust can also occur on the heads. Stripe rust and leaf rust overwinter on wheat and rapidly increase during the spring. Stripe rust develops during the cool temperatures of early spring. Leaf rust develops at warmer temperatures later in the spring. 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 or reduce the disease.

Historical Importance. In the late 1950's and early 1960's stripe rust caused losses in excess of 50 percent. Destructive epidemics of the rust have occurred in fields of susceptible varieties in 17 of the last 22 years. Stripe rust reduced yields in the Pacific Northwest by more than 20 percent in 1981 and more than 15 percent in 1983. Without development of resistant varieties and emergency registration of a new fungicide (Bayleton) for rust control, losses would have exceeded 50 percent in 1981 and 30 percent in 1983. As we develop varieties with better stripe rust resistance, leaf rust becomes more important because tissue not damaged by stripe rust is damaged by the later developing leaf rust. Consequently, leaf rust has become increasingly more important since 1962. In 1974, losses in Twin spring wheat exceeded 50 percent. Within the last 11 years, leaf rust has caused severe losses in every year except 1977, 1979, and 1982. Leaf rust is consistently severe in irrigated fields, and losses caused by the rust in those fields have sometimes exceeded 60 percent. Within the last five years stem rust has damaged wheat in eastern Washington and Oregon and northern Idaho, especially in late maturing fields.

Losses and Resistance. In 1984, the mean losses in yield caused by stripe rust, leaf rust, and stem rust in northwestern United States were about 10 percent, 5 percent, and 1 percent, respectively. However, in some fields of susceptible varieties, stripe rust and/or leaf rust reduced potential yields by more than 20 percent; and in parts of some fields in eastern Washington and Oregon and northern Idaho, stem rust reduced potential yields by more than 30 percent. Stripe rust was most severe in fields of varieties with resistance from PI 178383 (especially Jacmar, Moro, Barbee, Faro, and Weston) and in fields of Tyee. Varieties with the more durable, high-temperature, adult-plant resistance to stripe rust were not affected by new races. Leaf rust reduced yields of most winter wheat varieties and some spring wheat varieties grown in the Pacific Northwest. Stem rust was most severe in late maturing winter wheats and spring barley. Several new varieties have been developed with improved resistance to stripe rust and leaf rust.

Monitoring Rust. Thirty-two races of *Puccinia striiformis,* the pathogen that causes stripe rust, have been identified. Races virulent on Fielder, Moro, Tyee and seedlings of Stephens and Daws were most prevalent in the Pacific Northwest. No significant new races of *Puccinia recondita,* the pathogen causing leaf rust, were detected in 1984. Most winter wheat varieties currently grown in the region are very susceptible to leaf rust. Consequently, there has been no major selective pressure for new races of leaf rust. Races of *Puccinia graminis,* the pathogen causing stem rust, were uniquely different from races in other regions of the United States. The characteristics of the races and their diversity is evidence that the new races originated from barberry plants.

Effect of Weather. As in past years, the continual presence of living wheat plants throughout the year has provided adequate inoculum for the initiation of new stripe rust and leaf rust epidemics. The model that we developed for predicting stripe rust proved to be accurate for the sixth year, and the winter component of the model was also applicable for predicting leaf rust. All three rusts developed in the early planted wheats in the fall of 1983, but the relatively cool winter eliminated stem rust and reduced both leaf rust and stripe rust. However, a cool spring favored stripe rust development and frequent precipitation in May to July favored leaf rust and stem rust. Consequently, the rusts developed to severe intensity in some fields. Current evidence indicates that in 1984, straw on the surface because of minimum tillage and the presence of barberry bushes provided the primary source of stem rust inoculum, and wet weather in late spring provided a favorable environment for the rust.

Use of Fungicides. Since 1981, Bayleton has been used to control stripe rust and leaf rust in the Pacific Northwest when existing varieties become susceptible to new races and in combination with various types of resistance. Guidelines for the use of Bayleton have been developed based on type of rust, type of resistance, intensity of rust, stage of growth, potential yield, and economic return. New fungicides that show promise as foliar applications for control of stripe rust, leaf rust and stem rust are HWG-1608 and KWG-519 developed by Mobay, RH-3866 developed by Rohm and Haas, Tilt developed by Ciba Geigy, BAS-421F developed by BASF, DPX-H6573 developed by Dupont, XE-779 developed by Chevron, and EL-288 developed by Elanco. Baytan has potential as a seed treatment for control of stripe rust and leaf rust early but not late in the season and it must be managed carefully, because it can sometimes reduce the rate of growth.

SNOW MOLD RESULTS

G. W. Bruehl

Moderate snow mold attacked the wheats uniformly in the nursery 3 miles north of Waterville. The new soft white wheat, "John," rated slightly below Sprague in snow mold resistance but it passed its test. The proposed hard red selection, WA 6820 (= 77-99) also rated below Sprague in snow mold resistance but it passed the test in my judgment.

John, the soft white, is under increase (breeder seed) this summer. The hard red may require some selection before increase, but this wheat has unusual yield potential for a hard red and it should be released in the future.

Dr. Donaldson is screening the hard red in the hope of increasing its resistance to smut. I hope to improve its quality before release.

Both proposed new wheats also passed in a snow mold test in Okanogan County.

The most promising breeding lines will be given to the breeders at the end of this growing season.

CEPHALOSPORIUM STRIPE

G. W. Bruehl

The big bad news is that soil acidity greatly increases infection of winter wheat by *Cephalosporium gramineum*. Connie Love, a graduate student working on her master's degree, found that infection occurs in acid soils, especially pH 4.5-5.0, even without winter injury. The pH of many soils has been dropping constantly with heavy use of ammonium fertilizers, and use of lime may soon be a necessity on some soils. This work was supported by O. A. Vogel Research Funds.

Studies with Drs. Murray and Allen indicate, that so far as varieties are concerned, on a long-term basis, only truly susceptible wheats need be avoided. Stephens, McDermid, Hyslop and Brevor are the most susceptible wheats of present or historical significance.

A regular, sustained rotation with winter cereals once every three years is the main recommended control measure.

TAKE-ALL, *PYTHIUM* ROOT ROT, AND *RHIZOCTONIA* BARE PATCH

R. J. Cook, D. M. Weller, E. N. Bassett, and J. W. Sitton
USDA, Agricultural Research Service

Take-all and *Pythium* root rot are the two main root diseases of wheat and possibly also of barley in eastern Washington. Both diseases are favored by recropping (wheat after wheat or barley). *Rhizoctonia* bare patch also occurs on wheat and barley in the Northwest, but is less common. All three diseases are generally more severe with reduced or no tillage compared with conventional clean tillage. All three diseases are favored by cool, moist soils; they tend to be more important, therefore, in the higher rainfall areas, e.g. greater than 16-18 inches annual precipitation, and in the low to intermediate rainfall areas in unusually wet years and with irrigation.

Take-all is a problem in areas or years receiving more than 22-24 inches of water as precipitation or precipitation plus irrigation annually. With no-till, on the other hand, the disease can be severe in the 18-22 inch rainfall area of eastern Washington, but is rare regardless of tillage system in the intermediate rainfall area. It is probably the most important production constraint for irrigated wheat in central Washington. Symptoms include blackened roots, and the lower 1-2 inches of the stems of severely diseased 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 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.

The best control for take-all is crop rotation, i.e. do not grow wheat or barley in the same field more than once every two years. Potatoes, alfalfa, corn, beans, peas, and lentils are all nonhost crops. Irrigation water supplied in large but infrequent applications e.g., 3-4 inches every 7-10 days (as is possible with rill or solid-set systems) will 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. In fact, results of experimental trials with irrigated wheat make it abundantly clear that take-all control presently is not possible in consecutive wheat or barley crops without tillage. 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 but this control is ineffective if no tillage is used. 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. Yield increases of 10-25 percent are obtained about two-thirds of the time by use of these bacteria where take-all is the main yield-limiting factor. A practical method of seed treatment is still needed before this method can be used commercially.

Pythium root rot is responsible for loss of root hairs and branch roots on wheat and barley. The disease will also result in seed decay and seedling blight and hence a thin stand. A typical effect of *Pythium* is distinctly smaller plants adjacent to larger more normal plants. The disease also results in fewer tillers, smaller heads, and nutrient-deficiency systems because of the lack of root hairs and branch roots needed to absorb nutrients. Yields of wheat in the high-production, annually cropped areas of eastern Washington would be 20-40 bu/a greater with the same water and current rates of fertilizer if *Pythium* could be controlled completely. The disease occurs to a remarkably uniform degree in wheat and barley fields of eastern Washington. It is because fields are so uniformly affected that the importance of this disease has gone unrecognized until recently. *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.

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. Apron is the only effective seed-treatment chemical found to date, but even this chemical is inadequate to control the disease. Many *Pythium* spp. are involved in this root-rot complex. Apron controls only about half of them. Nevertheless, Apron as a seed treatment has given significant yield 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 only field treatment effective at present is fumigation with chloropicrin or Telone C17. On a broadcast/incorporation basis, the minimum effective treatment is about 15 gal of chloropicrin per acre or 25 gal of Telone C17 per acre. These rates are uneconomical in spite of up to 40 bu/a greater yield in some trials. Some preliminary results indicate that significant *Pythium* control and yield increases are possible with about 1 gal chloropicrin/a injected below and to one side of the seed with the fertilizer at the time of sowing. These experiments are continuing.

Rhizoctonia bare patch was found in the U.S. for the first time in 1984, in six different fields of wheat or barley in the Pacific Northwest. The disease was first described about 50 years ago in Australia where it continues to occur to this day. Crop rotation is ineffective. The disease is favored by no-till. Virtually any amount of tillage to disturb the fungus habit will result in less disease. The importance or potential of this disease is unknown. Like take-all, it requires moist soil and may, therefore, represent no threat in the low and intermediate rainfall area except in wet years or if irrigated. A limited study on effectiveness of seed treatment chemicals is underway at Lind with no-till spring barley.

INHIBITORY BACTERIA ON WINTER WHEAT ROOTS

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Large numbers of bacteria inhibitory to winter wheat growth can be present on the wheat root surface. Seeding into heavy wheat residues (till or no-till) seems to encourage the presence of these bacteria on the roots. Isolates of the bacteria that are inhibitory will colonize straw when they are added to it and are capable of persisting for long periods of time. In no-till seedings into heavy residues, severe stand loss can result in the chaff row. The inhibitory bacteria appear to live well on the chaff and we have been able to isolate large numbers of these organisms from chaff in the field.

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. The organisms appear somewhat specific. Isolates from winter wheat have much less effect on barley and little effect on oats, peas, and lentils. Studies are underway to determine if other inhibitory pseudomonads colonize barley, peas, and lentils and are inhibitory to their growth.

Field tests show that winter wheat seed inoculated with these bacteria produce plants that are inhibited and the bacteria are present on the root surface.

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.

Financial assistance from the O. A. Vogel Fund is gratefully acknowledged.

STRAWBREAKER FOOT ROT AND *CEPHALOSPORIUM* STRIPE

T. D. Murray

Strawbreaker foot rot and *cephalosporium* stripe are serious diseases of winter wheat in eastern Washington. These diseases can occur together in the same field. Both diseases are favored by early seeding and short rotations. Symptoms of strawbreaker foot rot include an elliptical or eye-shaped lesion near the stem base, usually yellow-brown in color with dark-colored 'scurf' in the center of the lesion. *Cephalosporium* stripe symptoms include yellow stripes extending from the tips of leaf blades down the leaf sheath. Stripes appear on every leaf in about the same position. After heading, one can cut through the upper nodes of the stem lengthwise and find dark discoloration in the node.

The best controls for strawbreaker include fungicides and resistant varieties. It is important to maintain effective fungicides for the control of strawbreaker foot rot. In Europe where fungicides have been used intensively for many years, some strains of the fungus causing foot rot are resistant to Benlate, Mertect, and Topsin. We surveyed for strains of this fungus and found only one strain resistant to these fungicides. We do not believe that a problem will develop with resistance to fungicides in Washington. Several new and old fungicides are being tested for control of strawbreaker foot rot including Benlate, Mertect, and Topsin. New fungicides with different modes of action are being tested with the goal of using combinations of fungicides that will prevent the development of resistant strains. Last year seed treatments were tested for control of strawbreaker, but were not effective. Benlate, Mertect and Topsin were all effective in controlling strawbreaker, but cephalosporium stripe prevented us from obtaining valid yield data.

Resistance to strawbreaker is being studied in both adult plants and seedlings. Adult plant resistance is correlated with seedling resistance and the development of a seedling test for resistance may be possible. Seedlings were artificially inoculated in a growth chamber and the infection process was followed. We found that resistant varieties prevent the fungus from penetrating leaf sheaths more effectively than susceptible varieties. This technique is being used to study the inheritance of resistance in progeny of crosses between resistant and susceptible parents to determine if we can detect resistance in early generation plants. We are also looking at a test to detect a chemical compound, lignin, produced during the infection process. This test would speed the evaluation of progeny from crosses and reduce the labor involved in screening for resistance.

Currently there are no chemicals for control of *cephalosporium* stripe, so we must rely on cultural control and resistance. A variety trial to screen for resistance to *cephalosporium* stripe including commercial soft white wheats, some hard red wheats, and resistant lines from Montana and Kansas was planted at Pullman. Symptoms are developing and we will be able to determine if resistant varieties from Montana and Kansas will be resistant under our conditions. If so they will be used as sources of resistance to develop varieties adapted to Washington growing conditions.

Field plots were established to determine the effects of different tillage practices on *cephalosporium* stripe. It has been shown that reduced tillage favors survival of the fungus; however, other factors such as seeding date and heaving of seedbeds interact with tillage practices. Currently rotation is the best control for *cephalosporium* stripe. A two year rotation out of a winter cereal will provide enough time for the fungus to die-out. Shorter rotations are not as effective in controlling *cephalosporium* stripe.

SPRING WHEAT RESEARCH

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

General

WSU's spring wheat breeding activity is centered at Pullman to gain greater efficiency. Extensive evaluation and screening trials are conducted also in the low rainfall area at the Dry Land Research Unit 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), at Foundation Farms, Inc., Walla Walla (sprinkler irrigation) and at the WSU Wilkie Research Farm at Davenport (recrop and management trial). 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 the Western Regional Spring Wheat nursery and the Uniform Regional Hard Red Spring Wheat Nursery. This group of nurseries plus crossing blocks with considerable introduced materials, supplement the base of germplasm available for cross-breeding.

New Varieties and Their Characteristics

Waverly—developed in Washington and released in 1981 by the states of Washington and Idaho in cooperation with the USDA. 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 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 released in Washington and Oregon in cooperation with the USDA was released 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.

Penawawa—developed in Washington, and recommended in 1985 for release by Washington and Oregon Agr. Experiment stations in cooperation with the USDA as a replacement for Edwall. Penawawa carries much the same level of disease resistance as Edwall, and is a sister of Edwall from among later made selections. Penawawa has shown broader adaptation, a significant yield advantage and a highly significant advantage in grain test weight over other SWS wheats. Edwall has tended to produce grain slightly lower in test weight than Waverly, especially when grown under dry land conditions. Foundation and breeder seed of Penawawa will be available to growers in the spring of 1986. The varieties Dirkwin and Twin still may be grown somewhat, and while these varieties still are highly resistant to the prevailing stripe rust population, a new race able to attack Dirkwin and Twin is present in eastern Washington. This new race could cause damage to these varieties much like that seen with Fielder. Both also are highly susceptible to leaf rust, but do carry stem rust resistance. Penawawa, Edwall and Waverly are resistant to that race.

Advances in On-going Research

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

Of particular significance to growers, is that variety development has been greatly accelerated through the 2-crop/year "shuttle breeding" effort developed with the cooperation of the Crops Research Division of the Department of Scientific and Industrial Research in Lincoln (Christchurch) New Zealand. The New Zealand crop season in the southern hemisphere is essentially the opposite of ours. We grow some of their materials and share germplasm in a reciprocal arrangement now formalized. New stripe rust races have appeared in New Zealand, permitting us to select for broader based resistances complementary to our adult plant resistance of interest also to DSIR.

Soft White Spring Wheats

The initial phases of the "shuttle breeding" program already have been influential on progress toward the release of SWS wheats, Edwall and Penawawa (Tables 1-7), and have been especially effective toward the incorporation of a hessian fly resistance base in the breeding populations of the WSU spring wheat program. This project also has benefited considerably from the cooperation and input of Drs. J. Hatchett, USDA Manhattan, Kansas and Keith Pike, WSU, Prosser, Washington. One SWS selection from the early phase of this hessian fly resistance program, WA7183 (tables 6 and 7), is already in Western Regional and Washington State trials for its second of 3 necessary test years. Reselections and subselections of WA7183 for a possible breeder seed stock to be considered for possible 1987 release already have been made and extensive testing is under way. Sublines will be evaluated separately and sister selections are also in replanted yield trials. WA7183 was one of the highest yielding entries in the Washington trials in 1984.

Table 1. Preliminary nursery replicated yield performance of wheat selections 1980—Indication of yield potential

Accession	Pullman yield bu/a (tw)	Royal Slope bu/a (tw)
WA 6920	128(63.0)	154(64)
Fielder	54(57)	121(63.5)
Urquie	89.9(60	90(61)

Table 2. Average yield (bu/a) and test weight ( ) data on five spring wheats grown in Washington for four years—C. F. Konzak

	No. of Tests	Dirkwin	Waverly	Edwall	Penawawa
1981	3	70.7(57.3)	67.4(58.4)	79.4(58.3)	81.7(59.6)
1982	10	57.8(59.2)	56.7(60.9)	55.5(60.2)	64.0(62.2)
1983	10	77.8(59.3)	77.6(60.6)	82.2(60.9)	82.6(61.7)
1984	8	62.6(56.4)	61.0(57.9)	67.8(58.2)	70.0(59.9)
Average		67.2(58.1)	65.7(59.5)	71.2(59.4)	74.6(60.9)

Table 3. Yield data (bu/a) on seven spring wheats grown in Washington for three years (Dayton, Walla Walla, Pomeroy)—K. J. Morrison

	No. of Tests	Dirkwin	Waverly	Edwall	Penawawa
1981	3	45.7	36.4	36.8	40.1
1982	3	55.3	52.4	48.7	47.0
1983	3	36.0	31.3	27.5	34.2
Average					
2 yr.		45.7	41.9	38.1	40.6
3 yr.		45.7	40.0	37.7	40.4

Table 4. Yield data (bu/a) on five spring wheats grown at four locations in Washington

	No. of Tests	Dirkwin	Waverly	Edwall	Penawawa
Pullman	10	76.0	71.0	74.1	78.7
Lind	9	31.1	32.1	31.6	32.6
Royal Slope	9	98.6	100.0	109.4	116.6
Harrington	3	47.3	43.7	48.8	46.8

Table 5. Maturity, Disease, Pest Reactions SWS Wheats

	Stripe Rust	Leaf Rust	Stem Rust	Mildew	Hessian Fly	Rel. Heading Date
Waverly	MR	RMR	MR	S	S	+1
Edwall	RMR	RMR	R	S	S	0
Dirkwin	R	R	R	S	S	+1
Owens	R	R	R	S	S	+1
Penawawa	RMR	RMR	R	S	S	+1
WA7183	RMR	RMR	R	S	R	+1

Table 6. 1984 Yields (TW) SWS Wheats

	Waverly	Edwall	Dirkwin	Owens	Penawawa	WA7183
Harrington	40(60)	47(59)	44(55)	45(60)	47(58)	46(58)
Connell	47(60)	48(60)	46(58)	48(60)	41(62)	46(60)
Walla Walla	45(58)	39(58)	57(55)	33(60)	50(59)	43(57)
Pomeroy	44(58)	42(56)	39(57)	94(62)	37(59)	46(56)
Royal Slope	86(59)	57(58)	77(57)	73(57)	98(63)	87(62)
Pullman	60(59)	100(60)	73(57)	72(60)	74(61)	82(60)
Davenport	62(60)	69(58)	62(57)	62(62)	59(61)	57(60)
Lind	7(59)	47(58)	46(58)	44(60)	57(60)	45(60)

Table 7. 1984 Yields (TW) SWS Wheats

	Harrington	Connell	Walla Walla	Pomeroy	AV
Waverly	40(60)	47(60)	45(58)	44(58)	54(59)
Edwall	47(59)	48(60)	39(58)	42(56)	57(58)
Dirkwin	44(55)	46(58)	57(55)	39(57)	55(57)
Owens	45(60)	48(61)	48(58)	33(60)	56(60)
Penawawa	47(58)	41(62)	50(59)	37(59)	56(61)
WA7183	46(58)	46(60)	43(57)	46(56)	57(59)

Hard Red Spring Wheats

Considerable progress already has been made also toward the development of hessian fly resistant HRS wheats. Besides building the hessian fly resistance germplasm into breeding populations, we have isolated several high performing, good quality disease resistant lines from a genetics research cooperation program involving Japanese scientists. This cooperative effort also used the New Zealand increase program, and is the means by which the initial phase of the "shuttle breeding" program was achieved. We were fortunate that one of the parent lines selected for the genetics research also carried hessian fly resistance. The most advanced lines from these studies are included in Tri State

Regional Spring Wheat Nurseries. Progress also has been made toward enhancing the protein production capacity of our HRS wheats. One of the better performers from this project (but not in 1984) was WA 7075. As it may be good enough as a first release and replacement for Wampum, we plan to select lines for possible breeder seed stock. Several other possible high protein HRS lines are in the Tri State trials.

Table 8. 1984 Yields (TW) HRS Wheats

	McKay	Wampum	NK751	WA7075
Royal Slope	89(59)	98(61)	83(62)	79(60)
Pullman	72(61)	64(59)	59(60)	66(59)
Davenport	67(62)	61(60)	60(60)	57(61)
Lind	48(60)	48(59)	47(62)	49(60)
Connell	51(61)	44(59)	39(58)	43(58)
Harrington	44(59)	59(58)	43(58)	57(60)
Walla Walla	39(58)	38(58)	50(59)	40(57)
Pomeroy	43(58)	50(59)	48(59)	44(58)
Average	57(60)	56(60)	55(60)	53(59)

Facultative Wheats

The past two seasons have been especially effective in screening for cold hardiness in spring wheats. Most of the lines under test have already proved to have some merit from prior spring planted tests. The high survival of lines selected last year was repeated, although the survival of Urquie is greater this year than last. In addition several other cold hardy lines were identified. These results further confirm the feasibility of developing spring wheats with greater cold hardiness than Walladay, but which head several days before Walladay, and comparable to locally adapted standard spring wheats.

Commercial Variety Trial

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

In 1985, the only SWS private entry is Interworld Seed's 4120. It has good quality and disease resistance. Only the WSU entry WA7183 and UI's ID232, which are nearing consideration for release, carry hessian fly resistance. Other SWS lines or advanced experimentals also carry hessian fly resistance, but most entries are susceptible to the pest. Hessian fly resistance will be essential when spring wheats are grown extensively under no- or mini-till management systems, or near winter wheats so managed. Of the publicly developed SWS varieties, Waverly will likely be the most commonly grown in 1985, as ample seed supplies are available, and its disease resistance remains adequate. It will gradually be replaced by Edwall, which carries higher resistances to stripe rust, leaf rust and stem rust and has a better yield performance record. All other privately developed entries are hard red spring types: developed largely for the northern Great Plains region. Entries included come from CENEX, NAPB, Interworld Seeds, Firstline Seeds, Northrup King, and Western Plant Breeders.

Among the HRS wheats, McKay (ID) appears to be the current best performer next to Wampum. Wampum maintained its stripe and leaf rust resistance in 1984, but is highly susceptible to stem rust. McKay is resistant to local forms of all rusts. Other entries have not been evaluated sufficiently for comment. (see tables)

Locations and Management of Evaluation Trials

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

1. *Row spacing*—tests at Pullman and Lind cooperative with Dr. A. Ciha, USDA (now at Monsanto) showed an average 10% yield advantage for the 6", 12" row spacing. With the 6" spacing there may have been less within row seedling competition at the same seeding rate (lbs/a) while the closer spacing may have permitted earlier coverage of the soil to reduce water loss. All Spring Wheat research program evaluation trials were sown at the close spacing.

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

3. *Fertilizer application*—In 1985 we are testing the application of liquid fertilizer between the seeded rows, with a low level of dry fertilizer (16-20-0) applied as a starter with the seed. In 1986, we expect to apply liquid fertilizer also as a starter. We hope this practice will simplify the control of weeds and allow better use of fertilizers. However, with spring wheats it may be desirable to shank in the N as NH_4 or urea later in the fall rather than spring to move the fertilizers deeper into the rooting zone.

WILD OAT CONTROL IN NO-TILL WINTER WHEAT

A.G. Ogg, Jr. and F. L. Young
USDA, Agricultural Research Service

Wild oats continue to be one of the most widespread and troublesome weeds in spring-planted small grains in the Pacific Northwest. Recently, wild oats have become a serious problem in fall-planted wheat and especially in wheat planted under no-till production systems. Wild oat populations are highest in the wetter areas of north facing slopes and populations of 100 to 200 plants per m^2 are common. Previous research has shown that 10 wild oats/m^2 can reduce wheat yields by about 10% and populations of 100 wild oats/m^2 can reduce wheat yields by 30%.

Currently available herbicides for control of wild oats were developed for wheat grown under conventional tillage systems and little if any information is available on the performance of these herbicides against wild oats in wheat grown under no-till production systems. Also, several new herbicides with potential for controlling wild oats need to be evaluated under no-till production systems.

A field experiment was established in the fall of 1984 to evaluate the performance of herbicides for wild oat control and for their effect on the growth and yield of Daws winter wheat grown under a no-till production system. Wheat was planted in paired-rows on October 17, 1984 with the USDA-Yielder drill. Triallate (Far-go) and trifluralin (Treflan) herbicides were applied to separate plots just prior to or immediately after the wheat was planted.

In the spring, 11 herbicide treatments were applied when the largest wild oats had 4 leaves. Wild oat herbicides applied in the spring included diclofop-methyl (Hoelon), difenzoquat (Avenge), barban (Carbyne), and AC-222, 293 (Assert). These herbicides were also applied in combination with clopyralid (Lontrel), a new herbicide with activity against Canada thistle and certain other broadleaf weeds. The purpose of the combinations is to evaluate potential antagonism (reduced weed control or increased crop injury) that can sometimes occur when herbicides are mixed together in the spray tank.

These research plots will be available for observation during the Palouse Conservation Station Field Day on June 27, 1985. Important results will be pointed out at that time.

BARLEY BREEDING AND TESTING IN WASHINGTON

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

Production

Barley production in 1984 in Washington was approximately 1.5 million tons (63.7 million bushels) from 960,000 acres. The state average yield was about 1.4 tons/a (60 bushels/a). Washington was the third largest barley producing state in the U.S. Planting projections for Washington for 1985 indicate that there will be over 1 million 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 equivalent or 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 Research Unit, the Mielke Farm in Harrington (winterhardiness), and the Royal Slope Research Unit (irrigated). Other major test sites are at Walla Walla, Dayton, Pomeroy, Davenport, and Connell. Dusty, Lamont, Cunningham, Deep Creek, Reardan, Bickleton, Mayview, Anatone, St. John, Uniontown, Fairfield, Farmington, and Wilbur are additional extension test locations. The cooperation of K. J. Morrison, C. F. Konzak and many growers in the testing effort is gratefully acknowledged.

An additional objective is to measure variety response to various cultural practices. This year the effects of growth regulators and nitrogen levels are being investigated at Pullman. Annual cropping system effects are being studied at Davenport (Wilke Res. & Ext. Farm), Harrington, Connell, Walla Walla and Pullman.

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 the newest 2-row spring barley which was released in 1983. Andre is recommended for malting and brewing and is superior to Steptoe in nutritional quality especially for swine and poultry. Long-term averages establish Andre as having higher yields than Vanguard, Klages, Kimberly, Lud and Advance and approaching Steptoe (Table 1,3,4). Andre has a high test weight, is plump

Table 1. Spring barley multipurpose cultivar yields.

Cultivar	1984 Pull.	Pom.	Day.	W.W.	Avg.	3 Year*-12 Loc. Yrs. Average	% of Steptoe
14583-77	85	59	87	82	79	70	96
Andre	88	68	90	68	79	76	104
Steptoe	86	76	98	82	85	73	100
Clark	95	69	77	85	81	69	95
Advance	84	54	83	85	77	65	89
Morex	79	48	71	57	64	55	75

Locations include Pullman, Pomeroy, Dayton and Walla Walla
*1982-84

Table 2. Spring barley multipurpose cultivar performance 5 year (1980-84) averages—Pullman.

	Plant Height	Lodging	Kernel Size	Test Weight	Heading Date
	-in-	-%-	-%-	-lb/bu-	-rank-
14583-77	37	17	88-3	52	4
Andre	36	17	85-5	55	6
Steptoe	38	25	92-3	50	2
Clark	38	18	94-3	54	5
Advance	35	21	78-7	50	1
Morex	42	25	88-5	52	3

Table 3. Yield performance of selected barleys at Lind and Davenport, 1983 and 1984.

Variety	Davenport 1983(F)	Davenport 1984(F)	Davenport 1984(C)	Lind 1983(F)	Lind 1984(F)	5 Loc-yr. Average	% of Steptoe
	bu/a						
14583-77	101	63	98	46	55	73	96
Steptoe	100	78	92	49	61	76	100
Advance	80	62	89	32	43	61	80
Andre	90	53	76	49	58	65	86

(F) Planted after summer fallow
(C) Continuously cropped

Table 4. Agronomic performance of 6-row barleys in Washington Extension Observation nurseries, 1983 (13 location averages) and 1984 (14 location averages).

Variety	Yield 1983	Yield 1984	$\bar{X}$	Test Weight 1983	Test Weight 1984	Plant Height 1983	Plant Height 1984	Lodging 1983	Lodging 1984
	----bu/a----			----bu/a----		-----in-----			
14583-77	73	68	71	47	42	32	34	18	16
Steptoe	75	78	77	47	43	29	34	29	37
Advance	64	72	68	45	43	28	32	19	52
Morex	59	58	59	47	45	35	32	37	60
Andre	68	59	64	50	45	29	38	25	20

and is equivalent to Klages in malting quality. The first certified seed was produced in 1984. Other 2-rows showing promise in advanced testing include the lines 8908-89, 8892-78, and 8771-78.

6-row Spring

Advance, WSU's most recent 6-row release was planted on about 8% (80,000 acres) of Washington's barley acreage in 1984. 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 72% of Washington's barley acreage in 1984. Each of the other spring varieties grown in 1984 was planted on 2% or less of the barley acreage.

Cougbar (WA14583-77) is a new 6-row spring multipurpose type barley which has been proposed for release. Cougbar's yield average overall in eastern Washington is 96% of Steptoe's yield (statistically equal to Steptoe). It has plump kernels, high test weight and less winterhardiness than Steptoe. Cougbar's yield, test weight and percent plump kernels has been greater than those of Advance. Cougbar has relatively good nutritional quality and is a potential malting barley (industry tests are incomplete). Comparative agronomic data are presented in Tables 1-4.

Several newer 6-row selections are showing promise in advanced testing. New 6-rows should have high yield, wide adaptation and good quality. The relative performance of several commercial varieties available in the state is presented in Tables 5 and 6.

Winter Barley

The 1984-85 winter was relatively long, cold and snowy throughout eastern Washington which meant variable winter barley survival. Several winter barley lines, particularly 6-row types, have yielded well over the past 4 years, including the semi-dwarf Showin. Showin is quite short and lodging resistant and has good yield potential, but the test weight tends to be low. Showin's winterhardiness is better than Boyer's and slightly less than Kamiak's. The yield potential for winter barley is very good, but winterhardiness is still a major limiting factor. Winter barley data is presented in Tables 7 and 8.

Table 5. Spring barley feed cultivar performance.

Cultivar	1984 Pull.	R.S.	Lind	Harr.	Ave.	Pullman 1984 TW	HT	Lodging
	bu/a					-lb/bu-	-in-	-%-
Steptoe	84	128	61	78	88	49	36	40
Kombar	80	120	47	53	75	46	29	8
Columbia	90	121	56	57	81	48	29	18
Gus	79	115	51	58	76	47	29	45
Lindy	-	-	60	71	-	-	-	-
Piston	93	109	63	61	82	53	32	20
Minuet	92	121	-	-	-	53	32	18
8359-80	87	128	62	69	87	49	34	45

Locations include Pullman, Royal Slope (irrigated), Lind and Harrington.

Table 6. Spring barley feed cultivar yields—3 year (1982-84) averages.

	Steptoe	Columbia	8359-80	Kombar	Gus	WB501	Gustoe
	bu/a						
PULL	100	98	97	94	86	77	82
R.S.	137	136	132	136	111	121	99
Mean	119	117	115	115	99	99	91

Locations are Pullman and Royal Slope (irrigated).

Table 7. Winter barley cultivar yield averages.

Cultivar	Pull. 5 yrs.	Pom. 3 yrs.	Day. 3 yrs.	W.W. 3 yrs.	14 Loc. Yrs.	% of Kamiak	% of Boyer
	bu/a						
Showin	121	91	110	127	114	107	106
Hesk	116	110	107	117	113	106	105
Boyer	116	87	103	119	108	101	100
Kamiak	110	93	102	120	107	100	99

Locations include Pullman, Pomeroy, Dayton, and Walla Walla.

Table 8. Winter barley cultivar performance.

Cultivar	Yield				Pullman 5 yr** Avg.			
	28 L.Y.+	% Kamiak+	44 L.Y.*	Kamiak*	Ht.	Lod.	Surv.	TW
	-bu/a-				-in-	-%-	-%-	-lb/bu-
Showin	107	114	95	119	33	4	97	47
Boyer	98	104	88	110	38	18	81	49
Kamiak	94	100	80	100	45	35	100	49
Hesk	-	-	-	-	40	22	89	49

+Pullman, Pomeroy, Dayton, Walla Walla 7 year averages (1977-84)
*11 extension locations over 4 years (1981-84)
**1980-84

FERTILIZER BANDING AND "FERTILIZER BURN"

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Extension Soil Scientist

Fertilizers are salts. They produce the same physiological effect on plants that ordinary salts do—if the fertilizer is present near the seed (seedling) at a sufficiently high rate. In the dryland crop producing area of eastern Washington, the usual rate of fertilizer used would not cause "fertilizer burn" if it was broadcast uniformly and incorporated into the top 5-6 inches of soil. Banding of the fertilizer concentrates the fertilizer. If this band and the seed band are close together the seed (seedlings) could be damaged. For example, an application of 100 lbs. of ammonium nitrate per acre (34 lbs. N) broadcast and worked into the soil would by no means pose a problem to the seedlings. Yet the same application banded with the seed (assuming a 1 foot row spacing) could damage the seedlings.

There is a routine and standard procedure for determining the salt content of soil—of determining whether there is sufficient salt in a soil to limit production. The procedure is used routinely in irrigated areas where natural salinity can be a problem. Knowledge gained from research on these types of soil shows that when a soil test shows a salt content of 4 mmhos/cm, some damage will be done to some crops in the seedling stage (mmhos/cm is the term used to express the degree of salinity—0-4 mmhos/cm causes little or no damage to crops; above 16, crops will not survive). If we assume that 100 lbs/a of ammonium nitrate was applied in a band with the seed row in 1 foot row spacings, and further assume that this salt would be dissolved uniformly in a 3 inch diameter band of soil around the seed, the salt reading (in a silt loam soil at field capacity) would be about 3.5 mmhos/cm. If row spacings are 6 inches apart the salt level would be one-half of this, or about 1.75 mmhos/cm. If the soil was drier than field capacity the salt concentration would be higher, and thus damage could occur. On the other hand, if rain comes just after fertilizing and planting, the salt level could be reduced to about 1 mmho/cm.

Since soil moisture supply is usually a major limiting factor in crop production, banding of fertilizer with the seed must be approached cautiously. This is why we suggest not exceeding 15 lbs N/a with the seed. Phosphorus does not produce the salt effect that nitrogen fertilizers do. The best solution to the problem is to place the fertilizer 3 or more inches away from the seed, then a few days after germination the seedling roots can reach into the "salt" (fertilizer) band to the degree they find safe. If the seed is in the middle of the fertilizer band it has no chance of avoiding the "salt" (and the salt concentration is actually greater in the center of the fertilizer band than it is away from the center).

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

F. J. Muehlbauer, S. C. Spaeth, J. L. Coker, and R. W. Short
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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 which are caused by a complex of several organisms are a major reason poor pea yields have been common to the area. Most of our efforts have been in identifying resistant lines for use as parents, hybridizing the resistant lines with commercial cultivars, and screening the resulting populations for root rot-resistant segregants with good plant type and adaptability. Because pea enation mosaic virus and pea leaf roll virus hae become extremely serious on peas and lentils in recent years, we have started screening for resistance in the field and greenhouse. Good resistance is available in peas, and we have recently identified resistance in lentils to pea enation mosaic virus. The goal is to incorporate resistance to these viruses into new cultivars.

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

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

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, on the average, 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.

'Emerald' is an improved lentil breeding line (#504) that has large green seeds and green cotyledons. The line has been proposed for release and breeder seed has been produced. Yields of Emerald are about equal to Brewer. Because of the green cotyledons, Emerald is considered a specialty type lentil.

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 1980-1984 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, ICCC 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.

Three chickpea lines have been proposed for release and include PI273879 (Garnet), ILC 517 (Noble), and CP-8 (Mammoth). These lines represent three different chickpea types and, therefore, are intended for different markets. PI273879 (Garnet) is an early maturing Desi type, ILC517 (Noble) is a small white Kabuli type, and CP-8 (Mammoth) is a large-seeded Kabuli type and also is characterized by its unifoliate leaves and early maturity.

BENEFITS OF LEGUMES IN ROTATION WITH CEREALS

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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.

USING LEGUMES IN ROTATIONS TO REDUCE OR REPLACE CHEMICALS

Walter A. Goldstein
Washington State University

Chemical purchase, application, and incorporation represent a large proportion of the operating costs incurred in farming in the Palouse. Recent estimates of costs for a wheat-pea rotation indicated that approximately 2/3 of the total variable costs incurred in growing winter wheat were either directly or indirectly associated with chemicals. With the low price of wheat and the high price of inputs it is becoming important to examine alternatives to chemical use.

Several management/rotational studies have been carried out to show to what extent N-fertilizer and herbicides can be replaced by forage legumes, green manures, animal manures and post emergence harrowing or rotary hoeing. Crop rotation studies were carried out on different sites with different levels of chemical or nonchemical inputs. Rotations included variable amounts of legumes. Legumes used in rotations were forage legumes and grain legumes. The forage legumes tested included alfalfa, black medic, and annual sweet clover. The grain legumes tested were lupines, chickpeas and peas; grain legumes were either plowed down for green manure or combined for seed. Winter wheat is presently being grown across all experiments; and some of the plots will be shown at Spillman Farm Field Day.

Results in 1984 showed that wheat with no fertilizer after black medic yielded as high as winter wheat with 150 lbs/a of N after barley. Though the number of weeds per unit area was similar between plots, winter wheat after medic outcompeted its weeds while winter wheat after barley did not. Yield of weeds at harvest was much higher (2665-4655 lbs/a) for the barley-wheat rotation than for the medic-wheat rotation (153 lbs/a), when plots were not treated with herbicides. Weeds were a mix of prickly lettuce, wild oats, purple mustard and fanweed.

The fact that including forage legumes in cereal rotations helped control weed problems was recognized already in the 1950's by Palouse agronomists, but the reason why was not understood. Greenhouse studies in 1985 of wheat-weed competition have indicated at least part of the reason why. When wheat was grown in soils which had been several years in cereal cropping or in several years of brome grass, root growth was reduced due to the activity of pathogenic root colonizing organisms (possibly *Pythium* and *Fusarium* species). Weed roots do not appear to be damaged by the same organisms and compete strongly for root space with diseased wheat roots. The competitive advantage is shifted in favor of the weed when wheat roots are diseased. When wheat was grown in soils which had been in medic or alfalfa, cereal root diseases were reduced and root growth was extensive. Consequently weed growth was restricted and weeds remained small. The lack of competitivity of wheat grown in cereal rich rotations necessitates a dependency on herbicides. The effect of green manure and forage legumes is not only to fix N but probably also to clear up root disease problems, and thus to help crops to compete with annual weeds.

Cereal growth and yields showed a marked drop when chemicals were removed on a site which had been 7 years in continuous cereal cropping before the rotation experiments began. Cereal growth and yields were high when chemicals were removed on a site which had been 4 years in alfalfa before rotation experiments began. The decrease of cereal growth and yields on the continous cereal site was probably due to a build-up of soil pathogens which pruned roots back and thus restricted nutrient uptake. Greenhouse studies of wheat grown in these soils showed restricted root development and diseased, pruned back roots. Field studies carried out on the continuous cereal site showed that when lupines and chickpeas followed on a break crop of clover + medic, they yielded approximately 40% higher than if they followed a previous crop of barley. Application of animal manure to a previous barley crop apparently decreased root disease in a following crop of peas. Animal manure, as well as rotations, probably decrease root disease severity.

Grain legumes are susceptible to root disease engendered by cereal rich rotations. When lupines were greenhouse grown in soils which had been in two years of medic, or two years of cereals, they showed marked differences in root development. Lupines grown after medic had approximately 2X more secondary roots and 3X more viable nodules in the top 30 cm than lupines grown after cereals. Lupines grown after cereals showed more roots infected with *Pythium* and *Fusarium* species. In contrast to this lupines did poorly after alfalfa which may be due to *Fusarium* species and weed problems encountered in the field.

To cut back on chemicals and to still maintain cereal yields it is necessary to change rotations and to introduce forage legumes or green manures. In Australian wheat growing areas annual medic or clover is used in rotation with cereals. These annual legumes are grazed lightly, then allowed to set seed, and then grazed heavily. Cereals are planted into the legume stubble and in the third year the annual legumes revolunteer. The advantages of this system over that of a green manure are: 1) the legumes do not need to be reseeded, 2) the legumes do not need to be plowed under, 3) the legumes provide excellent forage at certain time periods, 4) the system is relatively nonerosive. Studies in Pullman and Davenport indicate that the medics and clovers used in Australia are largely unsuited to our climate because they do not volunteer back well enough on the third year. This is possibly because our temperatures are not hot enough to cause pod breakdown and to decrease seed dormancy. Black medic, which grows wild in E. Washington, shows a good volunteering capacity, and may be well adapted to a medic-cereal rotational system. An economic comparison of a low chemical, minimum till medic-wheat-medic-barley rotation with a conventional wheat-pea-wheat-barley rotation showed higher gross returns and variable costs for the latter and higher returns over variable costs for the former. Due to these favorable economic results, it probably is important to refine and further examine the medic-cereal system.

RUNOFF AND EROSION PREDICTION

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. Knowledge of frost depth and extent is important to verification of erosion models. A network of thermometers and frost depth gages has been installed with cooperators in eastern Washington and northern Idaho. Data from the winter of 1984-85 illustrate the range of soil freezing conditions encountered across eastern Washington and the modifying influence of snow cover. At the time of deepest frost penetration, in mid-February, frost depths ranged from 4 inches at Pullman when snow depth was 11.5 inches to 34 inches between Hatton and Washtucna where the snow depth was almost nil. Because of the shallow frost depth and slow melting of the snow without excessive rainfall, erosion in the vicinity of Pullman was quite low. Other areas of the Palouse were not so fortunate.

Effects of Crop Management on Runoff and Erosion

Results of runoff and erosion studies at the Palouse Conservation Field Station in the winter of 1984-85 were strongly influenced by the lack of appreciable frost depth or excessive rainfall rate at the time of snowmelt. Runoff and erosion were lower than normal on all plots. During the winter of 1984-85 winter wheat following summer fallow yielded 0.5 inch of runoff and 0.5 ton per acre of soil loss; winter wheat following peas yielded 0.5 inch of runoff and 0.02 ton per acre of soil loss; whereas winter wheat following small grain yielded no runoff and no 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 winter of 1984-85 showed no run-off from slot-mulched wheat stubble plots compared to a modest amount of 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. 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 Washington.

Paraplow as a New Conservation Tillage Tool

The Paraplow manufactured by Howard Rotavator Co. 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 with virtually no disturbance of 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. Three years of trials have shown that it does indeed aid infiltration and reduce runoff and erosion. Measurements during the winter of 1984-85 showed virtually no run-off from paraplowed wheat stubble or pea residue plots compared to a modest amount of runoff and erosion from those conventionally tilled. Further tests will define where this implement will best fit into our rotations and determine its effectiveness.

CROP RESIDUE DECOMPOSITION

H. Collins, D. E. Stott, L. F. Elliott, G. S. Campbell, and R. I. Papendick
USDA, Agricultural Research Service

Knowledge of crop residue decomposition has become necessary as conservation tillage systems come into practice. Surface-managed crop residues can adversely affect seed placement and crop vigor. Other concerns addressed here include rate of plant residue decomposition and percent ground cover during critical erosion periods.

It is important to know the decomposition rate of surface-managed crop residue and the mechanisms of how residues decompose. It would seem that crop residues on the soil surface would decompose much slower than buried residues because of more favorable moisture and temperature relationships. However, observations indicate that surface residues in no-till seedings disappear fairly rapidly and the residues have almost disappeared from the soil surface at harvest. Field and laboratory studies (including complete environmental measurements) 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. While buried residues decompose more rapidly than those on the surface, the rate is not greatly different.

These studies will provide information for best crop residue management practices to prevent erosion and to increase crop growth. Studies are underway to construct a crop residue decomposition model so that rate of residue disappearance, soil protection during critical periods, and effects on soil stability can be predicted.

SOIL FERTILITY MANAGEMENT FIELD TRIALS FOR WHEAT PRODUCTION

Fred Koehler, Marvin Fischer, and Emmett Field

Field experiments concerning soil fertility management for wheat production are widely distributed throughout the wheat producing area of eastern Washington. 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; in 1983, 49% lower; and in 1984, only 5% lower.

When fall rains come too late to allow for germination and subsequent killing of weeds prior to seeding winter wheat, it is very difficult to control grassy weeds in a no-till system. In the winter of 1981-82 a new problem was encountered in the Colton area and again in 1982-83 in the Anatone 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 obvious reason.

At one location near Davenport, no-till has been compared with conventional tillage for 7 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 a series of maximum yield experiments over the last 4 years, the effect of phosphorus fertilizer on winter wheat yields has been studied. Maximum yields exceeded 100 bu/a at 6 of the 17 sites. At two of these high yielding sites where the soil test values for phosphorus were low, there were increases of 8 and 10 bu/a from the addition of phosphorus fertilizer. At the other sites there was little response to phosphorus. These data indicate that eastern Washington growers are doing a good job of maintaining adequate levels of phosphorus in their soil.

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.

SOFT WHITE WINTER WHEAT TOLERANCE TO CHLORSULFURON (Glean) AND OTHER HERBICIDES

Ralph E. Whitesides and Dean G. Swan—Washington State University Pullman

Chlorsulfuron (Glean) has shown excellent control of broadleaf weeds in winter wheat. Four varieties of soft white winter wheat, Daws, Hill, Lewjain, and Stephens, were treated with chlorsulfuron (0.25 oz ai/A) at the 2- to 3-leaf, 3- to 5-tiller, and the 4-node growth stage. For comparison 2,4-D LVE, MCPA LVE, bromoxynil, and bromoxynil plus MCPA LVE were applied at the same growth stages. No visible symptoms could be detected during the growing season. However, when 0.75 lb ae/A of 2,4-D LVE was applied at the 2- to 3-leaf stage of growth 13 to 15% yield reductions were measured on all varieties. Hill and Lewjain yields were also reduced from application of 2,4-D LVE (0.75 lb ae/A or MCPA LVE (0.75 lb ae/A) at the 4-node stage of growth.

Stephens wheat yields were reduced from 2,4-D LVE and MCPA LVE applied at the 2- to 3-leaf and the 4-node growth stages. Stephens yields were not reduced by applications of bromoxynil (0.38 lb ai/A), bromoxynil (0.38 ai/A) plus MCPA LVE (0.38 lb ai/A), or chlorsulfuron when compared to the untreated control. To further clarify the herbicide sensitive growth stages in soft white winter wheat, the variety Stephens was treated with 2,4-D LVE, MCPA LVE, bromoxynil, bromoxynil plus MCPA LVE, and chlorsulfuron at the 3- to 6-tiller, 1-node, 2-node, 3-node, and 4-node stages of growth. The incidence of crop injury from herbicides progressed as the wheat was treated at the later, larger stages of growth. In general, all herbicides applied from the tillered through the 2-node stage did not reduce wheat yield. Applications at the 3-node and 4-node stages reduced yield regardless of the treatment. Among the herbicides tested, however, chlorsulfuron caused no injury or the least injury at all stages of growth tested.

EFFECTS OF N AND P FERTILIZER MANAGEMENT ON EMERGENCE, SEEDLING VIGOR, AND MAXIMUM YIELD LEVELS OF NO-TILL WINTER WHEAT IN THE PACIFIC NORTHWEST

V. L. Cochran, R. I. Papendick and L. F. Elliott
USDA, Agricultural Research Service

Field experiments were established at three locations in the Palouse region of Washington and Idaho to determine the effect of applying 0, 33, 66, or 100% of either SCU-20 (sulfur-coated urea, 37-0-0-10) or UUP (urea urea phosphate, 36-12-0) in the seed row with the rest in the deep band below and between rows of no-till winter wheat planted in paired-row configuration. MAP (monoammonium phosphate, 11-55-0) was applied as the phosphate source with SCU-20, either in the same seed row vs. deep band ratio as SCU-20, or all in the deep band. A comparison of these treatments was also made with anhydrous NH_3 in the deep band and 0, 33, 66, and 100% of MAP in the seed row and the rest in the deep band to test P placement. All N rates were 120 lbs N/A and P rates were 40 lbs P_2O_5/a. There were no differences in stand counts among the different fertilizer treatments at any given location; however, visual observations indicated that early plant growth was reduced with the SCU-20 and UUP treatments where all of the fertilizer was placed with the seed. There was a trend for lower yields (often 10 percent or more) when all of the fertilizer was placed with the seed, but the reduction was not consistent nor always significant at all locations, regardless of material used. Yields were less reduced or not at all where only a part of the fertilizer was placed with the seed and the remainder in the deep band. Only one of the three sites responded to P application. Fertilizer treatments had no effect on grain test weights at any given location.

RUSSIAN THISTLE STUDIES

F. L. Young and R. E. Whitesides
USDA/ARS and WSU

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 the first year 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. Russian thistle was not as competitive the second year and these contrasting results may have been due to planting date of the crop and environmental conditions during the growing season.

A subsequent study on the area of influence of Russian thistle is presently being conducted. The objective of this study is to measure the distance from an individual thistle plant that wheat growth and development is reduced.

A third on-going study involving Russian thistle is to evaluate several herbicides and combinations of herbicides for the postharvest control of Russian thistle, residual control during the summerfallow year, and the effect of these herbicides on the seed germination of thistle.

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.

GRASS COMPARISONS FOR EROSION CONTROL

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

On March 1, 1977 eleven grass species and one legume, Ladak alfalfa, *Medicago sativa*, were seeded alone and as an overstory with 7 grasses at the Dry Land Research Unit, in Adams County, Washington. The planting was replicated three times in a randomized block design. Overstory species were seeded with a standard double disc drill on 12-inch row spacings. The planting was cross-seeded with understory species using the same drill but with 6-inch row spacings.

Species Seeded as Overstory

Nordan, *Agropyron desertorum*
Alkar, *Agropyron elongatum*
Greenar, *Agropyron intermedium*
P-27, *Agropyron sibiricum*
Secar, *Agropyron spicatum*
Whitmar, *Ag. spicatum f. inerme*
Luna, *Agropyron trichophorum*
Topar, *Agropyron trichophorum*
Magnar, *Elymus cinereus*
P-210, *Psathyrostachys juncea*
Ladak, *Medicago sativa*
Sherman, *Poa ampla*

Species Seeded as Understory

P-1822, *Agropyron dasystachyum*
Nordan, *Agropyron desertorum*
Sodar, *Agropyron riparium*
Covar, *Festuca ovina*
P-4874, *Poa bulbosa*
Sherman, *Poa ampla*
Canbar, *Poa canbyi*

During the fall of the establishment year, average plant density was 4.2 plants per square foot. This provided approximately 30 percent ground cover. The stand was considered adequate for continued evaluation. The overall planting was rated excellent in 1979.

The Mt. St. Helens volcanic eruption occurred May 18, 1980. On June 2, 1980 compacted ash at the Lind Dry Land Research Unit measured one inch. Approximately 1.7 inches of rainfall fell in May 1980. The May precipitation average for the 43-year period 1921 through 1963 at Lind is 0.79.

The ash had forced grass (old and new growth) down and covered some plant crowns. How much the cataclysmic effects of the volcanic ash are influencing the current trends are not fully known.

These project plots were evaluated on May 30 and 31, 1984. Several observations were made at that time which are as follows.

1. Sherman big bluegrass is a very aggressive species on the site and an excellent performer.
2. The Sherman is all headed except for the newly establishing seedling plants.
3. Very little Canbar is headed at this time.
4. Approximately 50 percent of the Nordan is headed.
5. Nordan is the only *Agropyron* species heading this date.
6. The Russian wildrye grass is all headed.
7. Magnar has no heads.
8. Rows seeded are generally no longer distinguishable on most species; however, they are very prominent with Secar, somewhat less with Whitmar and generally erratic with Sherman.
9. Very few broadleaf weeds appeared on this date in any of the plots with the exception of some occasional prickly lettuce.
10. Little cheatgrass occurs. That which does appear usually is in a plot with a rhizomerous perennial grass species such as P-1822, Luna or Topar. This same situation occurs in other projects here at Lind.

The attached table summarizes (3 replications) those plots which were established to a given species, alone or in a mixture, and have established to provide 70 percent or more ground cover by those seeded species.

Sherman, big bluegrass generally is providing the most ground cover. All 24 plots in which Sherman was seeded as an overstory species have 70 percent or more total ground cover. In 37 of the 39 plots in which it was seeded as an understory the plot is providing 70 percent or more ground cover. Sherman has invaded many plots and filled voids left by non-performers where it was not seeded.

Secar, bluebunch wheatgrass was seeded only as an overstory species. Where it appears 22 of the 24 plots have 70 percent or more total ground cover. Secar is providing 71.8 percent of the ground cover in plots where used as an overstory compared to 78.2 percent where Sherman appears as the overstory with the same understory species.

Whitmar is providing 32.1 percent of the total cover where it appears as an overstory, Ladak 17.3 percent, Nordan 6.9 percent, P-27 4.0 percent, Luna 2.8 percent, and Topar 0.8 percent.

There are 309 total seeded plots in the project (excludes three open check plots). Of these 309 plots the species seeded is providing 70 percent or more cover in 80 or 25.9 percent. Of these, 24 plots contain Sherman as an overstory, 22 contain Secar as an overstory and 37 contain Sherman as an understory. In other words, there are only 3 plots exceeding 70 percent ground cover which do not contain either Sherman or Secar. The three are Whitmar-Nordan, Whitmar-Sodar and Whitmar-Canbar.

Table 1. Overstory and understory species at the Lind Dry Land Research Unit seeded originally alone or as a mixture, which in 1984 were providing 70 percent or more ground cover. Average of three replications rounded to nearest whole number.

P-27	Sherman	2	80	82	Greenar	Sherman	0	82	82
Nordan	Sherman	T	82	82	Ladak	Sherman	10	72	82
Magnar	Sherman	T	80	80	P-210	Sherman	5	68	73
NS	Sherman	0	85	87	Secar	NS	70	0	73
Sherman	NS	80	0	80	Secar	Covar	82	2	85
Sherman	Nordan	90	2	92	Secar	P-4874	82	0	83
Sherman	Covar	73	7	80	Secar	Sodar	72	2	77
Sherman	P-4874	77	0	77	Secar	Canbar	68	5	73
Sherman	Sodar	77	12	88	Secar	Sherman	77	5	82
Sherman	Canbar	68	8	77	Secar	P-1822	73	3	77
Sherman	Sherman	87/		87	Luna	Sherman	T	80	80
Sherman	P-1822	73	10	83	Alkar	Sherman	T	77	77

% overstory / % understory   % total cover

NS = Not seeded

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USDA Western Wheat Quality Laboratory

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Cereal Diseases

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Pullman .... Cereal Viruses, Foot Rots and Other Diseases
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J.W. Hendrix, Pullman .... Leaf Rust Wheat Septoria
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PUBLICATIONS ON WHEAT, BARLEY, OATS, PEAS AND LENTILS AVAILABLE FROM WASHINGTON STATE UNIVERSITY

Dry Pea Production, EB0582
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