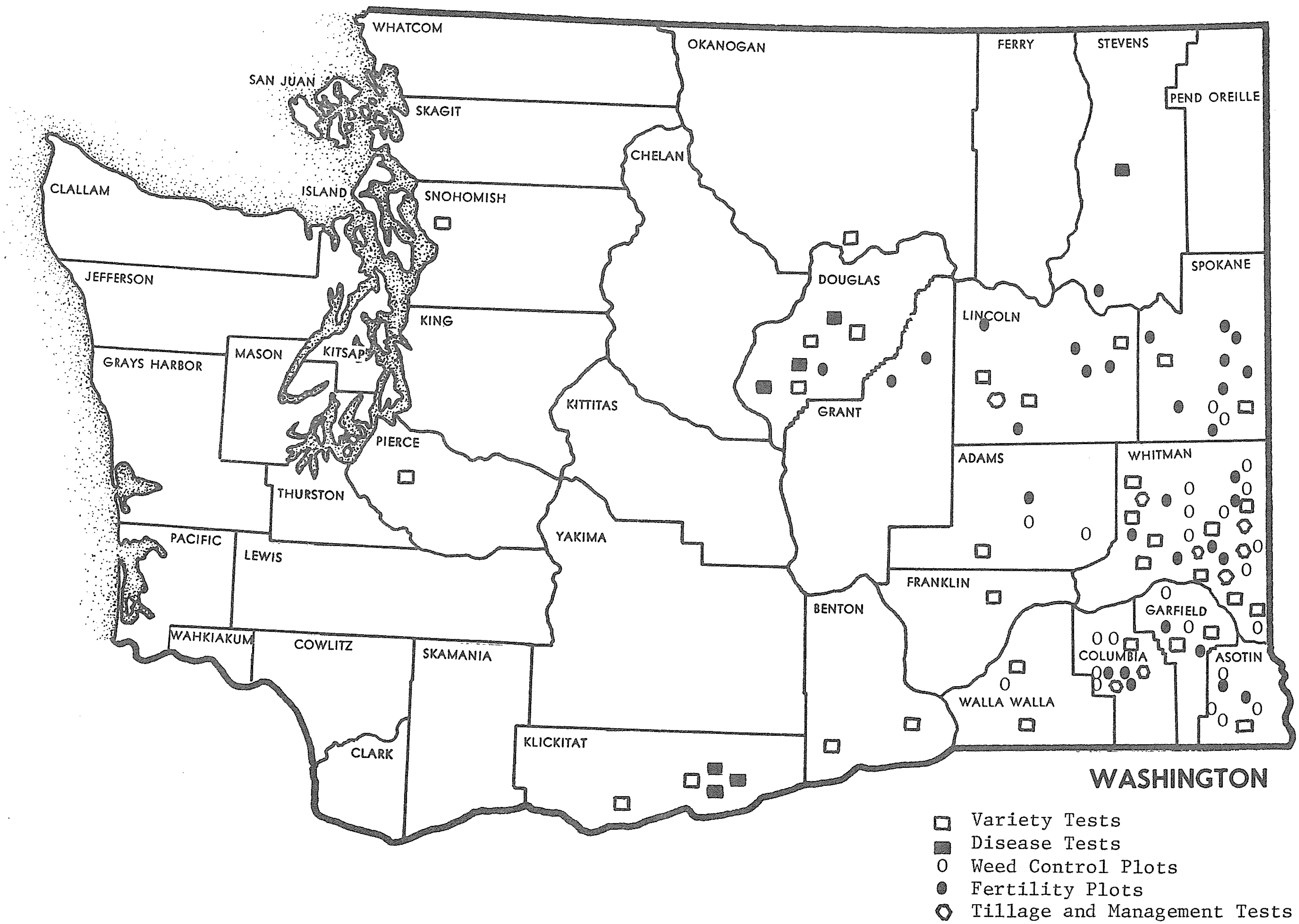
WSU FIELD DAYS

June 26, 1979
Dry Land Research Unit, Lind

June 27, 1979
Palouse Conservation Station
Field Day, Pullman

July 5, 1979
Spillman Farm, Pullman


WHATCOM
OKANOGAN
FERRY
STEVENS
PEND OREILLE
SAN JUAN
SKAGIT
CHELAN
CLALLAM
ISLAND
SNOHOMISH
JEFFERSON
DOUGLAS
SPOKANE
LINCOLN
KING
MASON
KITSAP
GRAYS HARBOR
KITTITAS
GRANT
PIERCE
ADAMS
WHITMAN
THURSTON
YAKIMA
PACIFIC
LEWIS
FRANKLIN
BENTON
GARFIELD
WAHKIAKUM
COWLITZ
SKAMANIA
COLUMBIA
ASOTIN
WALLA WALLA
CLARK
KLICKITAT
WASHINGTON
Variety Tests
Disease Tests
Weed Control Plots
Fertility Plots
Tillage and Management Tests

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. Dr. 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 certain problems, which, because of special conditions such as climate, soil, etc., cannot be studied at a central station." For over fifty years this station has followed this policy of studying the problems associated with the 8 to 12 inch rainfall area.

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

The present facilities include a machine storage built shortly after the station was established. The old barn was dismantled in April 1973 and the residence in 1979. A small elevator was constructed in 1937 for grain storage. A modern office and attached greenhouse were built in 1949 after the old office quarters were burned. In 1960 a 40' x 80' metal shop was constructed with WSU general building funds. In 1964 an addition to the greenhouse was built with a Washington Wheat Commissions grant of $12,000 to facilitiate breeding for stripe rust resistance. In 1966 a new deep well was drilled testing over 430 gallons per minute. A pump and irrigation system were installed in 1967. With the addition of a 12' x 60' trailer house residence improvements in 1966 and 1967 amounted to over $35,000 with more than $11,000 of this from Wheat Commission funds and the remainder from state funds. The major portion of the research has centered around wheat. Variety adaptation, wheat production management including weed and disease control, and wheat breeding are the major programs of research in recent years. Twenty acres of land can be irrigated for research trials. Although many varieties of wheat have been recommended from variety trials by the station, Wanser and McCall were the first varieties developed on the station by plant breeding.

Since 1916 an annual field day has been held to show farmers and interested businessmen the research on the station. This year marks the 62nd 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 was 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. 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.

George Varner, was appointed farm manager in 1974.

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 summer fallow and crop years.

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

Month	Temperature °F.		Precipitation		Precipitation
	Max.	Min.	1978	1979	57 yrs. av. (in)
January	34	22	1.15	.79	1.03
February	42	24	1.01	1.07	.87
March	53	32	.58	.74	.73
April	63	35	1.62	1.64	.63
May	72	42	.76		.75
June	83	45	.36		.89
July	90	52	.52		.24
August	90	50	.67		.34
September	79	45	.71		.54
October	65	38	.03		.87
November	47	29	.68		1.21
December	37	26	.88		1.29
			8.97		9.39

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 1. Temperature and precipitation at Palouse Conservation Field Station, Pullman, 1978 and 1979

Month	Average Temperature °F Max.	Average Temperature °F Min.	Precipitation 30-yr avg.	Precipitation Monthly	Precipitation Total Accum.	Deviation from avg. Monthly	Deviation from avg. Accum.
1978							
January	35.9	26.8	2.67	2.00	2.00	-0.67	-0.67
February	40.7	30.0	2.10	2.54	4.54	+0.44	-0.23
March	50.9	31.2	2.12	0.97	5.51	-1.15	-1.38
April	53.2	35.6	1.49	2.74	8.25	+1.25	-0.13
May	59.9	39.5	1.46	1.46	9.71	0.00	-0.13
June	72.9	45.6	1.54	0.61	10.32	-0.93	-1.06
July	79.4	50.5	.39	0.89	11.21	+0.50	-0.56
August	77.2	50.3	.52	1.18	12.39	+0.66	+0.10
September	67.3	44.5	1.08	1.30	13.69	+0.22	+0.32
October	62.5	33.4	1.91	0.06	13.75	-1.85	-1.53
November	38.2	22.2	2.47	2.68	16.43	+0.21	-1.32
December	30.6	16.6	2.74	1.81	18.24	-0.93	-2.25
TOTAL			20.49		18.24		-2.25
1979							
January	21.7	7.1	2.67	1.24	1.24	-1.43	-1.43
February	36.6	24.5	2.10	3.81	5.05	+1.71	+0.28
March	49.2	32.3	2.12	1.75	6.80	-0.37	-0.09
April	53.0	36.2	1.49	2.67	9.47	+1.18	+1.09
May 15*			1.46	1.59	11.06	+0.13	+1.22
TOTAL			9.84		11.06		+1.22
1979 CROP Year Sept. 1978-May 15, 1979			18.04		16.84		-1.20

*Partial month

RECOMMENDED VARIETIES - WHEAT, OATS, BARLEY

AREA	WINTER WHEAT	SPRING WHEAT	OATS	SPRING BARLEY	WINTER BARLEY
EASTERN WASHINGTON 14 Inches or More Rainfall	Nugaines Luke Paha Hyslop McDermid Daws Barbee Stephens Faro	Fielder Urquie	Cayuse Park Appaloosa	Steptoe Advance Larker - malting barley Belford - for hay only Vanguard - malting barley Blazer - malting barley	Kamiak Boyer
EASTERN WASHINGTON Less Than 14 Inches Rainfall	Wanser McCall Moro Paha Nugaines Sprague Barbee Faro	Sawtell Wampum Wared Twin		Steptoe	
CENTRAL WASHINGTON Under Irrigation	Nugaines Hyslop Daws Stephens Walladay Wandell (Durum)	Fielder Urquie Sawtell Wared Wampum	Cayuse Park Appaloosa	Steptoe Belford - for hay only	Boyer
Snow Mold Areas	Sprague				

WHEAT, OATS, AND BARLEY

Dr. Kenneth J. Morrison
Extension Agronomist
Washington State University

Winter Wheat

Nugaines

Nugaines is a soft white semi-dwarf 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 the hard red winter wheats 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. Nugaines was developed by SEA-USDA and Washington State University.

Luke

Luke is a soft white semi-dwarf winter wheat. Luke is resistant to most races of common and dwarf bunt and is well-adapted to areas where dwarf bunt is a problem. This variety is slightly better than most commercial varieties in resistance to *Cercosporella* foot rot, snow mold, and stripe rust.

Luke is less winterhardy than Nugaines. The milling quality is unusually good for soft white wheat and the baking quality is similar to Nugaines. Its resistance to lodging and shattering are slightly less than that of Nugaines. Luke is susceptible to leaf rust and flag smut. It emerges well for a semi-dwarf. Luke was developed by SEA-USDA and Washington State University.

Daws

Daws is a soft white common semi-dwarf 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.

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, and dwarf smut. Daws was developed by SEA-USDA and Washington State University.

McDermid

McDermid is a semi-dwarf soft white common winter wheat. It has weaker straw than Hyslop. McDermid has more winterhardiness than Hyslop but is not as hardy as Nugaines.

McDermid is similar to Nugaines in common smut reaction but is susceptible to most races of dwarf smut. The variety is resistant to stripe rust and leaf rust, and intermediate in reaction to mildew and *Septoria.* McDermid has shown a slightly lower yield than Nugaines in yield trials in Washington. The variety has performed the best in the north-central areas of Oregon and southern areas of Washington. It is susceptible to *Cephlosporium* stripe.

McDermid was developed by Oregon State University.

Hyslop

Hyslop is a soft white semi-dwarf winter wheat that yields well in high rainfall areas or with irrigation. Hyslop has a slightly better yield record than Nugaines where winterkilling is not a factor. Insufficient winterhardiness limits the use of Hyslop in eastern Washington. Coldhardiness tests have shown Hyslop to lack the winterhardiness of such varieties as Paha, Luke, McDermid, and Nugaines.

Hyslop is resistant to common bunt, stripe and leaf rusts, moderately resistant to mildew, and susceptible to flag smut.

Milling and baking qualities of Hyslop are similar to Nugaines.

Hyslop was developed by Oregon State University.

Sprague

Sprague is a soft white common wheat developed for the snow mold areas. The chaff varies from white to gray-brown and the heads are small and awned. It has high tillering capacity from early seedings, 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 rust, leaf rust, and *Cercosporella* foot rot.

It has excellent emergence and adequate winterhardiness.

Sprague was developed by SEA-USDA and Washington State University.

Barbee

Barbee is a semi-dwarf soft white club winter wheat with a bearded head. The variety has a slightly higher yield record than other club wheats. Barbee is not as good as other club wheats in emergence.

The variety has good stripe rust resistance and is resistant to flag smut and most races of dwarf smut. It produces an excellent flour but it mills more like a soft white common wheat variety than a club wheat variety.

Barbee is expected to replace Paha because of the higher yield record and better stripe rust resistance.

Barbee was developed by SEA-USDA and Washington State University.

Paha

Paha is a short, standard height, white club wheat variety. It is susceptible to some races of stripe rust, leaf rust, powdery mildew, and flag smut. It has moderate resistance to *Cercosporella* foot rot. The variety is resistant to lodging and shattering. Good germination and emergence characteristics of the selection are similar to other club wheats but not as good as Moro.

The variety is adapted to areas that produce the quality of club wheat desired by domestic and foreign markets.

Moro

Moro is a soft white club winter wheat with brown chaff.

Its chief advantages are resistance to stripe rust and excellent emergence.

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 a good pastry flour; however, it has a higher flour viscosity than older 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 better than other varieties from deep seedings in dry, dusty seedbeds.

Moro was developed by Oregon State University.

Wanser and McCall

Wanser and McCall are hard red winter wheats developed for low rainfall areas of Washington. Both varieties yield well in areas that have less than 13 inches of annual rainfall.

The two varieties can be distinguished by chaff color. Wanser has a brown-chaffed head; 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 is highly resistant to flag smut.

Wanser is recommended for the southern half of the Big Bend. Its 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 this area. McCall recovers rapidly in the spring which is another advantage for the northern area.

McCall has good winterhardiness, though less than Wanser. Both Wanser and McCall are more winterhardy than Nugaines or the club wheats.

Wanser and McCall are shatter resistant.

Wanser mills somewhat better than McCall. McCall has slightly better bread-baking quality than Wanser. Neither is suitable for production of soft white wheat products.

Wanser and McCall were developed by Washington State University and SEA-USDA.

Spring Wheats

Urquie

Urquie is a semi-dwarf soft white spring wheat developed by Washington State University and SEA-USDA.

Urquie is intended as a replacement for Marfed. Urquie is similar to Marfed in dual purpose baking properties but distinctly superior in milling yield, and generally superior to Marfed in grain yield, test weight, and other features. is also more lodging resistant than Marfed and has distinctly superior cold tolerance. The test weight of Urquie is equal to that of Fielder and Marfed, and superior to that of Twin. Urquie is expected to yield competitively with Fielder and Twin, especially in the dry land areas of Washington. Urquie is resistant to many prevalent races of stripe rust but is susceptible to leaf rust and has moderate susceptibility to mildew.

Fielder

Fielder is a soft white spring wheat developed by SEA-USDA and the Idaho Branch Experiment Station at Aberdeen, Idaho. Fielder is a semi-dwarf, stiff-strawed, white-chaffed, awned variety with moderate resistance to leaf rust, moderate resistance to prevalent races of stripe rust, but is moderately susceptible to mildew. Fielder has established a higher yield record than Twin or Marfed in the higher rainfall areas of eastern Washington. Fielder yields about the same as Marfed in lower rainfall areas. Test weight of Fielder averages about 2 pounds per bushel more than Twin and about the same as Marfed.

Fielder has only pastry quality, but has milling properties superior to Marfed.

Walladay

Walladay is a soft white facultative spring wheat released by Washington Agricultural Research Center and the SEA-USDA. Walladay heads from very late spring plantings at Pullman, while showing high winter survival from fall plantings. Facultative wheats can be seeded in the spring or fall. Walladay is similar in general appearance to its Luke parent.

The variety has produced high yields from both spring and fall plantings. The winterhardiness of Walladay is adequate for areas in southeast Washington but probably is not equal to that of standard winter wheats in areas or seasons with severe winters.

Walladay is medium height, semi-dwarf, white-chaffed, with stiff white straw. It is a bearded variety with soft to semi-soft kernels. The straw height averages about two or three inches shorter than Urquie and Fielder under higher rainfall conditions. Walladay is resistant to stripe rust in the adult stages but susceptible in the seedling stage. Its leaf rust resistance is superior to Fielder and Urquie. It is less dwarf bunt resistant than Luke. It is susceptible to stem rust and mildew. Walladay is very susceptible to *Cercosporella* foot rot.

Wared

Wared is a hard red spring wheat evaluated and released by Washington State University and SEA-USDA. The original crosses and selections were made in Minnesota as part of the United States Department of Agriculture, Agriculture Research Service, and University of Minnesota wheat research programs. Wared has an awned, white-chaffed head with semi-dwarf plant-type growth. The variety is slightly earlier maturing than Marfed. Wared has a higher yield record than Peak 72, and has excellent milling and baking qualities when grown on dryland or with irrigation.

Wampum

Wampum is a hard red spring wheat. The straw is standard or tall but is lodging resistant. Yields are slightly higher than Wared. It is resistant to leaf and stripe rust.

Wampum has excellent milling and baking properties for bread.

Wampum was developed by Washington State University and SEA-USDA.

Sawtell

Sawtell is a semi-dwarf hard red spring wheat developed by the SEA-USDA at the Aberdeen, Idaho, station and was released in 1977 jointly by Idaho, Oregon, and Washington. In Washington, Sawtell has shown higher yield potential under low rainfall conditions than other hard red spring wheats. Under irrigation, its performance has not been exceptional but appears similar to other hard red spring wheats. Under some conditions, it has tended to produce a grain of about 1 percent lower protein than other hard red spring varieties. Sawtell carries moderate resistance to stripe and leaf rusts and is moderately susceptible to mildew. In 1976, Sawtell was moderately susceptible to stripe rust at Pullman.

Spring Barley

Steptoe

Steptoe is a six-row, rough-awned, spring feed barley with a higher yield record than Unitan or Gem. The test weight is higher than Gem and about equal to Unitan. Steptoe heads about the same time as Unitan and about five days later than Gem. The variety has stiff straw with better lodging resistance than either Gem or Unitan. The straw is about the same height as Gem but 3 to 4 inches shorter than Unitan. The heads are erect with rough awns; the seed and the kernels are the same size as Gem, but slightly larger than Unitan. Steptoe is recommended to replace Gem and Unitan. The variety is not acceptable for malting.

Steptoe was developed by Washington State University.

Advance

Advance is a six-row spring variety with good potential as a malting variety. The variety has low or no cold tolerance and, therefore, it is very likely to winterkill which will reduce the problem of volunteer barley in subsequent crop rotations. This is especially important when wheat is grown after barley.

Advance is five days earlier than Steptoe and eight days earlier than Blazer. This extreme earliness will permit Advance to mature under more favorable conditions. Advance is 2 inches shorter and has stiffer straw than Steptoe, and is 5 inches shorter than Blazer. Additional tests indicate that Advance has a higher feed value for livestock than Steptoe but it yields only 93 percent as much grain as Steptoe. Advance has some susceptibility to mildew but in trials where this disease has been prevalent yield losses were not detectable and malting quality was not impaired.

Advance has a tendency to develop thinner kernels under adverse conditions. The variety does produce more plump and less thin kernels than Blazer.

Advance was developed at Washington State University.

Blazer

Blazer, a six-row malting-type barley with rough awns, was developed at Washington State University.

Blazer is expected to replace Traill and Larker, midwest malting barleys presently grown in Washington, Oregon, and Idaho.

Blazer produces higher yields than Traill and Larker and has greater resistance to shattering and lodging.

Blazer yields in eastern Washington have averaged 500 to 700 pounds higher than Traill and Larker.

Test weight of Blazer is slightly lower than Traill or Larker, but plump kernel percent is about the same as Traill.

The variety was developed by Washington State University.

Vanguard

Vanguard is a two-row malting barley recommended to replace Piroline. The variety has a 250-pound-per-acre higher yield record than Piroline. It has better lodging resistance. Vanguard matures about the same as Piroline and is the same height. It is a two-row, spring barley with rough awns. The seed size is slightly smaller than Piroline. The variety was developed at Washington State University.

Klages

Klages is a two-row malting barley adapted to production with irrigation. The variety is not well-adapted to low moisture dryland situations. Klages has been classified as acceptable for malting and brewing by the Malting Barley Improvement Association.

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 Vanguard but the malting quality exceeds Vanguard and Piroline.

Klages was developed by the University of Idaho.

Larker

Larker is a white-kerneled, semi-smooth-awned, six-row malting barley. It has moderate resistance to lodging, is high in test weight, and is about equal to Traill in height. Larker yields have averaged above Traill. It heads 2 or 3 days earlier than Traill. It is moderately susceptible to the smuts and powdery mildew and resistant to stem rust. It may have some tolerance to barley yellow dwarf virus.

Karl

Karl is a mid-season, white-kerneled, Traill-type malting barley with rough awns. The variety was developed by SEA-USDA and the University of Idaho. It averages about 8 percent higher than Traill in yield. Karl is usually 3 to 4 inches shorter and normally heads two days earlier than Traill. It has good test weight and kernel weight. It is slightly superior to Traill in shattering resistance.

Although Karl is generally equal to or superior to Traill in agronomic performance under irrigation, it is more susceptible to lodging and shattering than varieties such as Steptoe. It is not well-adapted to production on nonirrigated land in very low rainfall areas.

Belford

Belford is a six-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 for hay only in eastern Washington high rainfall areas and in central Washington under irrigation.

Winter Barley

Kamiak

Kamiak is a winter barley developed by Washington State University similar to Hudson in appearance. It has produced higher average yields than Hudson. It is about equal to Luther in most locations. Kamiak is equal to Hudson in winterhardiness with slightly larger kernel size than either Hudson or Luther. It is more lodging resistant than Hudson with shorter straw, but it is slightly taller than Luther. The test weight of Kamiak is higher than Luther, but slightly lower than Hudson. The variety matures about the same as Hudson but is at least ten days earlier than Luther. Kamiak does not have small, glume hairs which cause "itching" during the threshing of Luther.

Kamiak performs well in eastern Washington where Hudson was grown.

Boyer

Boyer is a winter barley developed at Washington State University. It is a six-row, white-chaffed variety with rough beards but it does not have the severe "itching" characteristics of other winter varieties such as Luther.

The high yielding, relatively short, stiff-strawed barley has a higher yield than Kamiak or Luther. Boyer is slightly more winterhardy than Luther and about equal to Kamiak. Boyer has shorter straw than the other winter barleys with 15 percent less lodging.

The kernels of Boyer are larger and plumper than other winter barleys. The seed of Boyer was available in 1976 for commercial production.

Oats

Cayuse

Cayuse is a high yielding, moderately early spring oat recommended in Washington. Cayuse was developed at Washington State University from selections 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 compared with 37 for Park.

Cayuse has fair tolerance to the most serious oat disease in Washington—yellow dwarf 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 in any Washington locations since testing began in 1959.

Although Cayuse is susceptible to node blackening and stem break, in the eastern part of the United States, these diseases do not affect oat yields in Washington.

Park

Park is an attractive, stiff-strawed, high yielding spring oat with plump, short, white kernels. It can be distinguished from most other oat varieties by its upright leaves, which are dark green in color. Park is a mid-season oat and is medium high. It rarely grows over 42 inches in height under irrigation. The heads are medium-short and erect. Park has yielded about the same as Cody or Shasta. Park is recommended to replace Cody because it has more uniform straw height and kernel size. Park can be grown in eastern Washington in areas with 14 or more inches of rainfall or on irrigated land in central Washington and in western Washington.

Appaloosa

Appaloosa is a yellow-gray spring oat released by the Washington Agricultural Research Center. Appaloosa has a higher yield record compared with Cayuse but a slightly lower average test weight. The variety is a mid-season spring oat with straw one to two inches shorter than Cayuse. It is more resistant to lodging. The groat and percent protein of Appaloosa are similar to Cayuse. Because of its greater barley yellow dwarf tolerance, Appaloosa is expected to replace the varieties Cayuse and Park for hay and grain production.

WINTER HARDINESS

Donald W. George and James Eldridge
USDA, SEA, AR

1978-79 provided us with a real "test winter," although the area of greatest severity did not include a winter hardiness nursery site. An early, persistent light snow cover and continuously frozen soil prevented any crown freezing tests and caused moderate winterkill at Pullman but essentially none at Central Ferry.

Area-wide low temperature episodes occurred on November 12-15 and again on December 31-January 1. The soil was bare at the time of the November cold; but a light snow cover of 1" to 2" was present over the Palouse-Blue Mountain Region, with the central and southern Basin essentially snow-free on January 1. Winterkill was very severe, with all varieties affected. While reports from the field agree that much wheat was killed in November, the area of severe injury appears to coincide with the January 1 bare soil area.

Where variety comparisons could be made, they were in general agreement with observations from previous years: Wanser (and Daws) were hardiest while Hyslop and Stephens appears to sustain the most injury. However, both Wanser and Daws sustained extensive injury in some instances and few reports were received of less hardy varieties surviving relatively well.

Apparently the season was such that planting date was unusually important in determining survival; early seeded (large plants) Wanser might have been severely injured while later-seeded Stephens or Hyslop survived. Exposure—physical protection by deep furrows, traces of snow, or by slope—played a large part in determining survival.

As has been reported previously, apparent survival early in the spring is generally much better than the final result. Stand continues to decline through March and April.

WINTER SURVIVAL

C. J. Peterson, R. E. Allan and Ed Donaldson
USDA, SEA, AR

Severe cold temperature with little or no snow cover killed or weakened winter wheat plants in a large part of Washington in 1978-79. None of the varieties survived in the coldest areas. The varieties responded to the cold temperature almost as we would have predicted (Table 1). The hard red winter wheats were the best. Daws was the best soft white winter wheat and Jacmar was the most winter hardy club. Walladay was the weakest. Stephens has about the same tolerance to cold as Hyslop.

Table 1. Data on the percent survival of 19 winter wheats at five locations in Washington (1978-79)

% Survival of the top growth

	Lind	Connell	Ritzville	Cunningham	Clyde	Avg.
Commons						
Kharkof	64	78	85	64		
Wanser	31	51			68	
McCall	59	55				
Hatton	57	51			66	
Daws	33	51	92	76	74	65
Greer	13	1	74	54	58	40
Nugaines	32	4	56	66	54	42
McDermid	16	5	61	54	69	41
Luke	8	2	57	44	52	33
Hyslop	4	0	37	31		
Stephens	1	0	18	18	46	17
Walladay			2	6	59	
Sprague	58	23	84			
Club						
Jacmar			84	76	68	
Moro	23	0	80	64		
Paha	11	1	51	48		
Barbee	12	9	61	66	62	42
Faro	16	0	46	48	59	34
Tyee			86	54	50	

BREEDING FOR RESISTANCE TO SPROUT DAMAGE–MANY PIECES TO THE PUZZLE

R. E. Allan, B. H. Hong, J. A. Pritchett
M. L. Baldridge and M. A. Patterson
USDA, SEA, AR

We are learning that breeding for resistance to sprouting in the head won't be easy–but we definitely can make progress. Last year Dr. B. H. Hong of South Korea finished up a three-year study on the various traits associated with sprouting, low post-harvest dormancy and high alpha amylase activity. The key findings from this work were:

1. The degree of post-harvest dormancy present when the rains come is the main trait that determines to what extent white wheats resist sprouting.

2. High alpha amylase activity also correlated with damage, but not always. Some varieties had low enzyme activity but still scored high for sprout damage.

3. Varieties that had tightly closed florets, such as Brevor, were also more resistant to sprouting.

4. Varieties with kernels that have wrinkled creases were more susceptible to sprouting. Apparently they soak up water more rapidly than kernels that have smooth-tight creases.

5. Red seed color was not necessarily associated with sprouting resistance.

6. Selection for dormant seed, closed florets, low alpha-amylase activity, early maturity, lax spike, tenacious glumes, heavy waxy bloom on the heads, short plant height and short or absent awns all contributed to sprouting resistance.

7. Sixteen wheat varieties were grown at Pullman, Lamont and Walla Walla for two years and we checked them for sprouting resistance, dormancy and alpha amylase activity. Varieties fairly resistant to sprouting at one location were usually resistant at another location that same year. However, several varieties proved to be extremely variable year to year at some locations for their resistance to sprouting and alpha amylase activity.

   These results warn us that we will need to test our material at several locations and over several seasons to be sure that we select types stable for resistance to sprouting.

8. Earlier maturity could be one way we might reduce sprout damage. Dr. Hong's tests showed that lines that headed 10 days later than their sister lines usually suffered a four-fold increase in sprout damage.

9. A particularly important finding was that some red and white wheat varieties have different genes for dormancy and that these traits can be combined to achieve selections more dormant and hence more sprout-resistant than either parent.

10. The F_3 populations of two crosses involving Sprague were tested to find out if we could select offsprings that emerge as well as Sprague, yet which have post-harvest dormancy levels at least comparable to Nugaines. The results indicate we can recover types that emerge fast yet have moderate dormancy.

SOFT WHITE WINTER WHEAT IMPROVEMENT

Clarence J. Peterson, Dave Henderson,
Steve Hayward and Mary Baldridge
USDA, SEA, AR

General Seasonal Conditions: Washington produced 133,980,000 bushels of wheat on 2,910,000 acres in 1977-78 for a 46-bushel-per-acre average. The 1977-78 winter was fairly open and mild. The precipitation received during the crop year (table 1), by most of the area, was slightly above average. Rain during August and September delayed harvest and part of the crop was damaged because of sprouted kernels. Cereal diseases reduced grain yields especially stripe rust, leaf rust, dwarf bunt and *Cercosporella* foot rot. The grain yields of early fall sown fields in the high rainfall areas were reduced up to 50% because of *Cercosporella* foot rot infection. Green bugs and oat bird-cherry aphids were a problem during the fall of 1977 in the early sown fields.

1. *New Promising Selections:*

Tyee (CI 13431/CI 17805/CI 13447/3*Omar) is a soft white club semidwarf winter wheat that is resistant to the local races of stripe rust. It is moderately resistant to common bunt and susceptible to powdery mildew, leaf rust, dwarf bunt and snow mold. Tyee has equalled or exceeded the grain yields of Paha and Barbee. The milling and flour qualities of Tyee are similar to those of Paha.

WA 6362 (Luke Mut. LM-14) is a soft white common semidwarf winter wheat that has adult resistance to the local races of stripe rust. It is also resistant to dwarf bunt, common bunt and moderately resistant to flag smut. WA 6362 is susceptible to snow mold and leaf rust. Grain yield of WA 6362 is slightly higher than that of Luke. The milling and flour characteristics of WA 6362 are similar to those of Luke. WA 6362 or WA 6363 are possible replacements for Luke.

WA 6363 (Luke/WA 5829) is a high yielding soft white common semidwarf winter wheat. It has resistance to stripe rust, common bunt, dwarf bunt and moderate resistance to leaf rust. It is susceptible to flag smut. Grain yield of WA 6363 is slightly higher than that of Luke. The milling and flour qualities are quite similar to those of Nugaines.

WA 6581 (VD 76217/VB67297, Sel. VD 75211) is a soft white semidwarf club winter wheat that has resistance to infection by stripe rust, common bunt, dwarf bunt, *Cephalosporium* stripe, flag smut and *Cercosporella* foot rot. It is susceptible to leaf rust and snow mold. WA 6581 has generally exceeded the grain yields of Faro and Barbee by at least 5%. Milling and flour quality of WA 6581 is excellent.

WA 6580 ((CI 14484)/K 691533 Sel. VH 75847) is a high yielding soft white common semidwarf winter wheat. It is resistant to stripe rust, *Cephalosporium* stripe and common bunt. It is moderately susceptible to leaf rust and susceptible to dwarf bunt and snow mold. The milling and flour quality of 6580 is very good.

WA 6470 ((VH 66438/VH 59287/CI 13438)/Norco Sel. VH 74333) is a soft white common semidwarf that has adult resistance to the stripe rust races presently occurring in the Pacific Northwest. It is resistant to flag smut and common bunt (res. factors 4-9). WA 6470 is susceptible to leaf rust, powdery mildew and *Cercosporella* foot rot. Grain yield of WA 6470 has been a little higher than that of Nugaines and Daws. Its milling and flour quality characteristics are similar to those of Nugaines.

WA 6471 (CI 15923//Nord Desprez/2*CI 13438 Sel. VH 75391) is a soft white common semidwarf that has adult resistance to stripe rust. It is tolerant to leaf rust and flag smut. It is resistant to common bunt (res. factors 1, 4). Grain yield of WA 6471 has been a little higher than that of Nugaines and Daws. WA 6471 has milling and quality characteristics similar to those of Nugaines.

Yield Data: The yield data obtained on the commercial winter wheats at ten locations in Washington is shown in Tables 1 and 2. The new winter wheats, Stephens, Daws and Greer performed quite good in 1977-78. Luke continues to perform well at some locations. Walladay is very susceptible to *Cercosporella* foot rot and therefore its yields were greatly reduced at some locations.

The club wheats, Tyee and Barbee, had the best overall yield at the ten locations. Limited amounts of seed of Tyee will be available for seeding this fall (1979).

Table 1. Date (bu/A) on 6 winter wheat varieties grown at 10 locations in Washington in 1977-78

	Stephens	Daws	Nugaines	Luke	Greer	Walladay
Deep Creek	73	102	77	88	96	77
Bickleton	23	25	21	29	24	22
Goldendale	33	30	24	36	34	17
Uniontown	104	103	87	98	92	93
Reardan	49	56	43	61	65	44
Dayton	93	102	89	87	87	89
Clyde	64	51	49	51	52	48
Dusty	63	52	57	62	65	56
Mayview	56	61	46	69	62	32
Lamont	43	47	42	54	52	51
Average	60	63	54	64	63	53

Table 2. Data (bu/A) on 5 club wheat varieties grown at 10 locations in Washington in 1977-78

	Paha	Tyee	WA 6472	Barbee	Faro
Deep Creek	59	76	71	78	76
Bickleton	29	24	34	30	17
Goldendale	28	44	37	38	33
Uniontown	50	91	88	80	94
Reardan	30	48	43	68	45
Dayton	80	89	79	82	76
Clyde	49	50	50	47	45
Dusty	52	59	52	55	46
Mayview	60	57	50	60	47
Lamont	54	52	57	54	48
Average	49	59	56	59	53

HARD RED WINTER WHEAT BREEDING AND TESTING

E. Donaldson and M. Nagamitsu

The Hard Red Winter Wheat Breeding and Testing programs in Washington are conducted from the Dry Land Research Unit at Lind. Primary emphasis is placed on increasing yields of winter wheats for the 8 to 12 inch rainfall areas by combining the higher yield potential of the soft white winter wheats with the better yielding hard red varieties and selections. Crosses are also made to incorporate the desired quality, disease resistance, rapid emergence, winterhardiness and agronomic traits into single lines. Every attempt is 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 into adapted varieties of high quality and disease resistance for the low rainfall area.

Selection recommended for release, Hatton, CI17772 (PI142522/2*McCall, WA 6364) is a hard red winter wheat with grain yields 10% better than Wanser. It has adult resistance to the stripe rust races presently found in the Pacific Northwest. It is white chaffed stiff strawed and taller than Wanser with a plant and head type similar to Wanser. Emergence growth habit and winterhardiness appear to be similar to Wanser. Weaknesses include a lack of adequate resistance to common bunt and the foot rots.

Disease Nurseries:

All the disease nurseries except the *Cercosporella Foot Rot* nursery on the Dry Land Research Unit and the snowmold nursery in Douglas Co. were eliminated by winter kill. There was no snowmold in Douglas Co. last winter. Only a few of the advanced foot rot resistant lines survived the winter. The *Cercosporella foot rot* resistant parents which have been used are somewhat weak in winterhardiness.

Last year in the Lind dry land nursery, barley yellow dwarf caused up to 50% reduction in yield when compared to the yields of the same selections in an uninfested nursery seeded one week later. Considerable variation in yield reduction between varieties was noted: Hatton showed 8%, Wanser 25%, and the new release from Idaho, Arbon showed 22% reduction in yield.

Some agronomic characteristics of recommended varieties and the older varieties they replace are given for five locations in eastern Washington in Table 1, Lind; 2, Horse Heaven Hills; 3, Connell; 4, Finley; and 5, Harrington. These data are from rod row nurseries. Data from these and other trials in eastern Washington are used to make variety recommendations. Variety recommendations for the different rainfall areas are included in this brochure in the section by Dr. Kenneth Morrison.

Table 1. Summary of agronomic characteristics of winter wheat varieties grown at Lind in rod row nurseries, 1952-78.

Variety	Av. Plant ht.	Av. Test wt.	1978 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. years grown
Nugaines	26	61.6	41.8	38.4	129	14
Luke	25	60.3	43.7	35.0	128	10
Sprague	27	60.7	44.9	34.5	130	8
Daws	31	59.4	45.6	36.7	131	5
Stephens	29	58.5	46.6	35.0	133	6
Moro	30	58.8	39.7	36.9	121	15
Paha	28	60.1	45.2	38.5	134	12
Faro	30	58.0	43.8	40.4	120	5
WA 6155	28	59.4	*	36.6	102	3
Barbee	27	58.8	41.8	38.3	139	6
Wanser	32	61.8	33.8	34.8	114	15
McCall	31	61.9	37.8	37.3	120	14
Hatton	32	62.4	41.8	34.1	143	3
Kharkof	33	60.5	24.5	29.7	100	24

*Not grown in 1978

Table 2. Summary of agronomic characteristics of winter wheat varieties grown in the Horse Heaven Hills in rod row nurseries, 1951-78.

Variety	Av. Test wt.	1978 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. years grown
Nugaines	60.1	16.3	19.5	122	8
Daws	59.0	13.3	11.9	102	3
Stephens	57.8	16.6	14.6	126	3
Moro	57.2	15.1	18.1	118	10
Paha	58.8	16.6	18.7	117	8
Faro	57.6	14.2	11.8	102	3
Barbee	56.6	14.3	8.2	91	2
Wanser	60.2	13.9	18.5	117	11
McCall	60.8	14.0	18.2	115	11
Hatton	62.4	14.7	11.9	103	3
Kharkof	60.0	15.2	17.3	100	18

Table 3. Summary of agronomic characteristics of winter wheat varieties grown at Connell in rod row nurseries, 1975-78.

Variety	Av. Test wt.	1978 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. years grown
Nugaines	62.1	28.4	33.1	110	4
Daws	60.1	31.2	32.3	119	3
Stephens	58.8	31.2	33.6	124	3
Moro	58.8	32.7	38.5	128	4
Paha	60.2	32.7	37.5	125	4
Faro	59.1	32.0	32.5	120	3
Barbee	59.2	28.3	23.2	110	2
Wanser	62.2	28.0	33.2	111	4
McCall	62.7	28.4	33.9	113	4
Hatton	63.8	28.2	31.5	116	3
Kharkof	61.1	22.6	30.1	100	4

Table 4. Summary of agronomic characteristics of winter wheat varieties grown at Finley in rod row nurseries, 1975-78.

Variety	Ave. Test wt.	1978 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. years grown
Nugaines	63.4	28.7	31.6	119	4
Daws	61.5	27.5	30.7	134	3
Stephens	60.2	23.9	28.6	125	3
Moro	60.4	23.4	36.4	138	4
Paha	61.6	27.7	36.3	137	4
Faro	60.5	31.8	31.4	137	3
Barbee	60.8	28.3	22.8	135	2
Wanser	63.5	19.8	30.0	106	4
McCall	63.7	20.7	28.8	109	4
Hatton	64.2	25.6	31.5	137	3
Kharkof	62.1	17.6	26.4	100	4

Table 5. Summary of agronomic characteristics of winter wheat varieties grown near Harrington in rod row nurseries, 1952-78.

Variety	Av. Test wt.	1978 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. years grown
Nugaines	61.9	40.9	39.6	134	13
Luke	60.9	46.7	41.0	142	10
Sprague	61.3	45.7	43.1	140	8
Daws	60.8	45.0	40.4	130	5
Stephens	59.3	46.7	41.0	132	5
Moro	59.3	45.3	38.6	131	13
Paha	60.5	44.0	40.3	141	11
Barbee	58.8	46.6	44.8	136	6
Faro	59.7	48.9	40.8	131	5
Wanser	62.4	40.1	38.2	131	12
McCall	62.8	*	41.0	143	11
Kharkof	61.3	32.8	34.0	100	25

*Not grown in 1978

SPRING WHEAT IMPROVEMENT

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

The spring wheat research in Washington is conducted utilizing mainly the research facilities at Pullman (medium rainfall), Lind (low rainfall), and Royal Slope in the Columbia Basin (irrigated), with offstation regional research trials via grower cooperation near Connell, Dayton, Harrington, the Horse Heaven, Pomeroy, Walla Walla and Waterville. Extension observation trials are conducted at these and a number of other locations in the wheat growing areas of Washington. New introduced varieties, lines, and plant selections also are being tested in preliminary nurseries, with each entry being evaluated at all three main locations during the same year. By this method it is possible to more quickly estimate the probable adaptation and potential of varieties and lines and to select those that warrant further and wider testing in the off-station trials.

The general scope of WSU spring wheat research is indicated by Table 1 which lists the trials and numbers of selections under evaluation in 1978 and 1979. Among the nurseries grown at the three station locations, several can be seen by those attending the field days, including the Regional Facultative Wheat Nursery and the Western Regional and Washington State Uniform Spring Wheat Nurseries. The Midwestern Uniform Regional Hard Spring Wheat Nursery and the International Spring Wheat Nursery (CIMMYT) are evaluated first at Pullman and sometimes with observation plots at Lind, if seed supplies are sufficient. The main crossing blocks and parental lines are grown at Pullman. Virtually all new crosses are made at that location because of the more favorable conditions for crossing and regular adaptability of new parental sources. Many new foreign introductions and other new germ plasm sources are evaluated and some used in crossing each year.

Objectives: Major emphasis in breeding and selection continues to be yield performance for specific and general conditions, with crosses being made to incorporate the necessary quality, disease resistance, cold tolerance (facultative characteristics), and desirable agronomic traits into adapted lines. Research to improve the potential for higher protein content and nutritional value of hard red wheats is receiving increased attention as is research on a dual purpose quality type. Preliminary single plot and replicated yield tests of some higher protein derivative hard spring wheat from crosses of local wheat with Argentine and other introductions are included in the 1979 research at Pullman and Royal Slope.

The 1979 Western Regional commercial variety and Washington State Spring Wheat Nurseries include new entries from the Washington State cereal research program and from the States of California, Idaho, and Utah as well as promising new entries from private breeders.

One of the major disease problems affecting estimates of yield potential in tests under irrigation, Barley yellow dwarf virus, may have been placed under control via sprays with systemic insecticide. Yields in 1978 on some lines exceed 120 bu/acre at Royal Slope. Many durums yielded over 125 bu/a. However, the situation with stripe and leaf rusts predicted from 1977 data, materialized even to a greater extent than expected, such that Fielder and Fieldwin types became 100% infected with the stripe rust race. May, 1978 plantings of these wheats at Pullman showed approximately probably 40% yield reduction. Urquie, Walladay and WS-1, as well as most WSU selections showed good resistance to stripe rust. However, the new leaf rust also was abundant in 1978, and while Fielder may have some resistance to this race, stripe rust infection took priority on available leaf space. Of the soft white cultivars only WS-1 showed moderate resistance. Moreover, even in the Advanced Washington State and Western Regional trials only one of the soft white entries WA6402 showed moderate resistance to both rusts. WA6402 has shown only average yield performance in other years, but has had sufficient testing to permit consideration as a potential stop-gap variety.

The serious rust problem has resulted in some major adjustments in the WSU program. All new WSU-developed state and regional entries now carry resistance to both rusts. These entries were selected from among lines promising from single plots tests in 1978, evaluated for quality trials and increased over the 1978-79 winter season in New Zealand via the cooperation of a local plant breeder there.

The new rust races pose a serious threat to soft white spring wheat production in the area, since nearly all of the winter wheats grown are highly susceptible to at least the leaf rust disease and provide inoculum to infect the spring wheats. A crash program effort was initiated to identify new resistance. The 1979 plantings already reflect the results of that effort. The crash program tests in 1972-78 showed that a large portion of very promising new high yielding selections from WSU, Idaho, and Oregon were susceptible to the new leaf rust race. Nevertheless, a number of resistant WSU lines have been identified. New crosses made in the greenhouse already incorporate new resistance sources identified in the fall of 1977, and in 1978. A winter 1977-78 increase in Chile of F_4 material from several crosses advanced new breeding lines into the selection stage. A winter 1978-79 increase of over 1000 new selections was made in New Zealand, with the result that many rust resistant good quality selections could be included in the 1979 regional trials, and in adaptation tests.

New Quality Development. A totally new combination of quality traits appears to have been achieved in a number of WSU soft white spring and facultative wheat lines. This new quality type combines the processing characteristics (bread and pastry properties) of typical hard red wheats with those of the common soft white wheats. With wheats having this combination of traits, Washington growers could have access to a wider selection of market channels, and compete more effectively with Australia for Asian markets, as well as in US specialty markets.

These wheats also should offer advantages to the PNW market in their suitability and blendability at all protein contents. Small pilot scale tests of lines having the new quality type are in progress and larger scale tests are planned for 1979-80. Some of the new dual quality wheats show competitive yield performance with current soft white spring wheats, but have inadequate disease resistance. Other new lines have disease resistance, but yield testing has just begun. Numerous new cross combinations have been made and more will be made to study the inheritance and recombination of the new traits.

VARIETY DEVELOPMENT

Soft White Spring and Facultative:

URQUIE–Developed at Washington State University with cooperation of USDA-SEA and released by Washington and Idaho in 1978 as a replacement for Marfed. This new high milling and baking quality common soft white semidwarf spring wheat variety carries an effective adult plant type of resistance to stripe rust. Urquie also produces better test weight grain than Twin under all cultural conditions. Earlier tests indicated that Urquie was better adapted to the low rainfall areas than either Fielder or Twin. Tests indicate that Urquie will perform as well as Twin and Fielder in the higher rainfall areas and under irrigation, while retaining its superiority in the low rainfall area.

The greater cold tolerance of Urquie compared with Marfed, Twin and Fielder should permit earlier spring planting which is desirable for achieving highest yields. A fair supply of registered and certified seed was available via WSCIA for 1979 planting.

WALLADAY—Increased in 1977 as WA6153. This semidwarf, facultative soft white common spring wheat was released in 1978. Walladay carries resistance to some races of leaf rust and is moderately to highly resistant to stripe rust, including the races that severely attacked Fielder and Fieldwin in 1978. Its quality is similar to Fielder. Performance tests to date indicate that Walladay has equal to greater yield potential than Fielder. Its later maturity than Twin or Fielder may permit higher yield potential under irrigated culture, but may be a disadvantage in late spring plantings. However, it has done well in moderately early plantings in the Dryland area. Walladay has greater cold tolerance than Urquie and may be suitable for late fall and mid winter and very early spring seedings in areas where this practice may be desirable or necessary due to severe freezing injury to winter wheats. Small foundation and additional breeder seed stock increases were produced in 1978. However, the stripe rust resistance of Walladay may not be adequate for fall seeding in areas of heavy stripe rust attack, as in Western Washington, and a new race of leaf rust, which also attacks Urquie, Dirkwin and Twin may be especially damaging on late spring planted crops.

Hard Red Spring Wheats:

SAWTELL—Formerly ID000047, a semidwarf hard red spring wheat developed by the USDA-SEA at the Aberdeen, Idaho station, was released in 1977 jointly by Idaho, Oregon and Washington. In Washington, Sawtell has shown comparatively higher yield potential under low rainfall conditions than other hard red spring wheats. Under irrigation its performance has not been exceptional but appears similar to other, better hard red spring wheats. Under some conditions, it has tended to produce grain of about 1% lower protein than other hard red spring varieties. Sawtell carries moderate resistance to stripe and leaf rusts and is moderately susceptible to mildew. Sawtell is susceptible to the new stripe rust and leaf rust races that attack Fieldwin.

WAMPUM—Formerly WA6105, developed by Washington State University with USDA-SEA cooperation, is a short standard height stiff-strawed hard red spring wheat with good milling and baking properties. Wampum tends to be better adapted to higher rainfall and irrigated culture than other hard red spring wheats and may find its widest use in that area except when needed for overplanting injured hard red winter wheats. Wampum appears to carry different types of resistance to stripe and leaf rusts than other hard red spring varieties now in production. It is also resistant to powdery mildew. Foundation and registered seed were produced in 1978. Wampum carries resistance to the new leaf and stripe rust races and may carry tolerance to barley yellow dwarf virus. Wampum achieved the overall highest yield record among wheats tested in Washington State trials in 1978.

Table 1. Research Trials and Number of Selections Under Test in WSU research

Nurseries	Coordinator	1978 Locations	1979 Locations	1978 Entries	1979 Entries
COOPERATIVE TRIALS--					
Western Regional Spring Wheat Nursery	USDA-MT	25(3)	25(3)	36	36
Western Facultative Wheat Nursery	WSU	9(5)	12(6)	12	12
Tri-State Spring Wheat Nursery (WA, ID, OR)	WSU	6(3)	7(3)	36	36
International Spring Nursery	CIMMYT-Mex	60(0)	60(1)	50	50
International Durum Yield Nursery	CIMMYT-Mex	27(1)	27(1)	25	25
Western Durum Nursery	WSU	5(1)	4(1)	32	36
International Durum Elite Nursery		12(0)	12(1)	––	50
International Spring Wheat Observation Nursery	CIMMYT-Mex	60(1)	60(1)	300	300
International Winter/Spring Wheat Observation Nursery	CIMMYT-OSU	25(1)	25(1)	250	250
WSU RESEARCH TRIALS--					
Commercial Variety Nursery	WSU	(4)	(3)	32	32
Washington State Regional SWS		(9)	(9)	33	33
Washington State Regional–HRS		(6)	(6)	27	27
WSU Advanced Trials (2nd season rep)		(3)	(3)	120	80
WSU Preliminary (1st season rep)		(3)	(3)	500	260
WSU Single Plot (4-row)		(1)	(2)	3500	4000
F_4 F_5 Single Row Evaluations		(1)	(1)	20000	30000
F_3 Bulks		(1)	(1)	500	300
F_2 Bulks		(1)	(1)	800	350
High protein lines		––	(2)	0	120

( ) Number of Washington State Locations

TRI-STATE SPRING WHEAT NURSERY

C. F. Konzak

The plant breeders in the three Northwest states cooperating on variety releases interchange advanced lines of spring wheats for preliminary regional tests one season before the best performing lines become candidates for entry into the Western Regional Spring Wheat Nursery. The Tri-State Spring Wheat Nursery thus serves to provide wider scale tests on a larger number of promising lines that would otherwise be possible, and tends to increase the possibility that those selections finally enter into the wider testing program will have variety potential for the Tri-State area.

COMMERCIAL VARIETY NURSERY

C. F. Konzak, M. A. Davis, and M. R. Wilson

Beginning in 1976, a new set of trials was established by WSU to evaluate promising new material developed by private plant breeders which would likely be produced for sale in Washington State. We invited private breeders to send us their advanced lines and current varieties for inclusion in these tests.

The 1979 nurseries include selections from five private breeders—Germains, North American Plant Breeders, Northrup King, Western Plant Breeders, and World Seeds. Growers attending the Field Days at any of the three main stations (Pullman, Lind and Royal Slope) will be able to observe and compare private as well as publicly developed wheats in this trial.

IMPROVING PROTEIN CONTENT AND NUTRITIONAL COMPOSITION

C. F. Konzak

Crosses made several years ago using germ plasm sources obtained from the Nebraska-USAID program and from several other sources have advanced to the stage where lines with potential for significantly increased contents of protein or dibasic amino acids (including lysine) have been identified. Some preliminary selections are now being tested for performance stability and adaptation in replicated trials at the three main stations. Other selections are being increased to permit confirming tests and wider evaluation while the best materials will be used as parents in further crosses.

Generally, the high protein germ plasm sources have been poorly adapted for local conditions and have poor processing, hence the early crosses have had little potential. Thus, several breeding cycles may be necessary to exploit the potential of these materials in developing competetive or higher yielding locally adapted varieties.

We now have identified selections with ability to produce a high content of probably more nutritious protein in the flour, as well as a few that from preliminary processing tests show promise for mixing and potential baking properties.

WESTERN REGIONAL SPRING WHEAT NURSERY

C. F. Konzak, M. A. Davis, M. R. Wilson
K. J. Morrison, P. Reisenauer, E. Donaldson, M. Nagamitsu

This cooperative research test of the performance potential and adaptation of spring wheats usually includes 25 to 36 entries, some soft white, a few hard white and a high proportion of hard red spring wheats. The nursery is grown at about 25 locations throughout the West, ranging from Canada to Arizona. WSU's 1979 entries include ten soft white and two hard red spring wheat selections.

Included along with this nursery at most test locations are a group of standard and recently released commercial varieties, and the Washington State Soft White Spring and State Hard Red Spring Wheat Regional Trials. Either the State Soft White or State Hard Red series is grown at several other sites in the state of Washington. The standard, commercial and recent varieties are included in all county extension trials of spring wheats in the state.

DURUM WHEAT IMPROVEMENT

C. F. Konzak and M. A. Davis

There is potential for a small, but significant acreage of durum wheat production especially in the irrigated Columbia Basin of Washington and Oregon. WSU tests have consistently proved that grain of acceptable to high processing quality can be produced in Washington, and that yields can be competitive with soft white or hard red spring wheats. The variety Wandell, the first U.S. semi-dwarf durum was developed by WSU in an effort to provide local irrigated growers access to the area markets for durum. While performing well agronomically, Wandell has a quality weakness in its tendency for producing grain high in yellow berry, a condition that reduces the market grade and thus income to the grower. Because durum must be handled as a separate, specialty or contract crop, this weakness has been serious. Central Washington growers of durum now have reasonably close access to the General Foods mill in Pendleton besides the Portland outlets, providing a ready market for this crop. Thus, a new variety is needed to permit irrigated growers an alternative to soft white wheat. WSU has carried on a small, but effective breeding and selection program for a number of years, and coordinates the Western Durum Nursery trials. Tests of CIMMYT's International Durum Nursery also are conducted at the Royal Slope farm. Based on results from 4 years' trials in the Western Durum Nursery, one WSU line, designated WA6292, has shown outstanding performance and advantages over Wandell in both Washington and Idaho tests. It not only has equal to or better yield than Wandell, but also has larger kernels and low yellow berry a high tendency to produce vitreous grain as desired by the industry. WA6292 is currently undergoing a preliminary breeder seed increase prior to consideration for recommendation as a release.

BARLEY BREEDING AND TESTING PROGRAMS IN WASHINGTON

R. A. Nilan, C. E. Muir, A. J. Lejeune,
K. J. Morrison, and P. E. Reisenauer

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 malting quality. When winter grown, they must have winterhardiness superior to the current winter barley varieties. This objective includes the development of "multipurpose" varieties that will be the highest yielding varieties available. Such varieties, whether 2-row, 6-row, spring or winter, will have quality that will meet malting industry standards. Because of their malting quality they should be superior in feed quality. Thus, they will meet all market demands for barley grown in this State.

The program involves the development of winter and spring, 2-row and 6-row multipurpose varieties at Pullman, selection and testing programs at Lind (dry land) and Davenport (winter-hardiness), and testing programs at Royal Slope and Quincy (irrigated), Walla Walla, Dayton, Pomeroy, Vancouver, Puyallup, and Mount Vernon.

The new 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 at Pullman are summarized in Table 1. This table also includes some advanced selections which will be discussed below.

6-row Spring

WA6591-69 was released in the spring of 1979 under the name 'Advance.' Its agronomic characteristics are described in the front of the brochure under recommended barley varieties for the State of Washington.

Advance was released without designation of its malting status. Industry plant scale testing for malting and brewing acceptability are underway on a 1978 crop carlot and will continue on the 1979 crop in much larger quantities. Prior extensive pilot scale tests are very encouraging and its malt analytical properties are similar to Larker, the 6-row standard of quality.

Advance was tested for nutritional quality and was judged to be superior to Steptoe and equal to the best 2-rows in nutritional value.

2-row Spring

The next 2-row malting variety will be released within the next three years and will come from four selections involving Klages crosses. These, e.g., WA9037-75, selections (Table 1) are now under preliminary increase for plant scale malting and brewing tests. These selections are higher yielding than Vanguard, Klages, or Kimberly, yield 90-95% of Steptoe, and have the quality of Klages. Release of one of these will reestablish the Palouse area as a major 2-row malting producing area, a market usurped by the superior qualities of Klages and Kimberly grown under irrigation in other areas.

Winter Barley

The new variety Boyer performed beyond expectations in 1978, its first year of commercial production, with some yields reported up to four tons per acre.

All new winter 6-row and 2-row selections are of the "multipurpose" type, i.e., high yield, suitable malting and feed quality. No selections are as advanced as those of the spring types, chiefly because these selections must also be winterhardy. More progress has been made with the 2-row than with the 6-row.

Because of the severe winter of 1978-79, Table 2 shows winter survival of the three important winter 6-row varieties at Pullman and Davenport in 1978-79 and the long-time average 1971-78 at Pullman. The 1978-79 data show less survival for Kamiak than Boyer and Luther at Pullman. Past records show the order to be more like that recorded for Davenport, with Kamiak hardiest and Boyer and Luther somewhat similar. However, other observations around the State indicate slightly better survival for Boyer than for Kamiak. These apparent discrepancies will be studied further.

Field Days

Visitors at Lind will see a number of the previously described varieties and selections (Table 1) in spring nurseries. Winter barleys did not survive at Lind.

Visitors at the Field Day at Pullman will have an opportunity to view in demonstration plots early and late seedings of 16 current varieties and new advanced selections of spring 6-row and 2-row and 16 current varieties and new advanced selections of 2-row and 6-row winter types.

Table 1. Comparative Yields of Barley Varieties and Types
Pullman, 5 Year Average (lbs. per acre)

Spring		Winter	
6-Row			
Feed		*Feed*	
Steptoe WSU	4603	Boyer WSU	5803
Unitan	4253	Kamiak WSU	5746
		Luther WSU	5381
		White Winter	4064
Malting		*Malting*	
Advance	4394	Under Development	
Blazer WSU	4186		
Traill-Larker Type	3322		
Karl	3259		
2-Row			
Malting		*Malting*	
WA9037-75	4498	Under Development	
Vanguard WSU		Sel. 2464-70 (Ack. 989 x R.T.H.) WSU	4860
Piroline	3864		
Kimberly	3662	Ackerman's 989	4697
Klages	3499		
Heines Hanna	3130		

Table 2. Winter Survival (%)

	Winter of 1978-79		1971-78
	Pullman	Davenport	Pullman
Boyer	27	30	99
Kamiak	14	50	100
Luther	36	35	98

TRITICALE

Clarence J. Peterson, Dave Henderson,
Steve Hayward and Mary Baldridge
USDA, SEA, AR

We screened triticale lines from CIMMYT, Alabama A&M University, Oregon State University, Jenkins Foundation and our program for agronomic and disease characteristics in 1977-78. Each year the new triticales appear to be a little better, and some of them are equalling or exceeding the grain yields of the best wheats. The test weights are gradually improving but protein content is going down. Winter hardiness is still a problem but if we have snow cover during the cold weather, most of them will survive.

6TA476 and VT75229 (tables 1 and 2) are the best triticale that we have grown over a number of years. 6TA476 was developed by Charlie Jenkins and we developed VT75229. Under some environmental conditions we still have some sterility problems with them.

Table 1. Data on triticales and winter wheats grown at Pullman, Washington in 1977-78 (Planted 9/27/77)

	Heading	Plant Height (inches)	Test Wt. (lbs/bu)	Yield (bu/A)	Yield Range (5 rep.)
Nugaines	6/9	37	50.9	87	70-99
6TA476	5/26	52	50.0	75	52-95
MY20	6/7	37	50.0	84	69-105
Daws	6/9	39	51.3	87	65-100
VT75229	5/26	52	49.1	83	53-97
MY13	6/5	35	47.9	90	85-105
VT76370	5/30	51	49.6	85	69-96

Table 2. 1978 spring triticale yield nursery grown in Pullman, Washington

	Test Wt. (lbs/bu)	Yield (bu/A)	Yield Range
Fielder	49.6	38	34-44
6TA476	44.9	46	37-56
VT75229	46.0	52	37-63
Urquie	49.9	47	35-53
MT76008	42.2	52	48-56
VT77895	45.1	58	52-69

FOLIAR DISEASE GENETIC STUDIES

R. E. Allan, R. F. Line, J. A. Pritchett, M. L. Baldridge
USDA, SEA, AR

Leaf Rust. Last year afforded us an excellent opportunity to assess our material for resistance to leaf rust, because the disease was particularly prevalent at Pullman. The majority of our germplasm is susceptible to both of the prevalent races of the leaf rust fungus which now occur in the Pacific Northwest. We do have a few advanced selections and numerous early generation lines which appear to have good field resistance. Over 20 advanced lines were identified to have useful resistance. They apparently derive their resistance from several sources, including Prof. Delos, Minister, Imperator, Cleo, Probus, Joel and Primepi (sources from northern Europe), Webster, PI 94349, Chinese 2*/*Agropyron elongatum*/Pawnee, Sel. 1/Orin and WA 3469 (sources from the Midwest and our own program).

Over 144 reselections were made among early generation plant lines expressing resistance to leaf rust. High levels of resistance have been derived from Ottawa sib/Renacimento, Chinese 2*/*Agropyron elongatum*/Pawnee, PI 94349, Falco, PI 245579, Ibis and Hyb. Jorque. We also reselected 139 lines from crosses involving Nugaines, Hyslop and Barbee, to the leaf rust resistant sources of Timpaw, CI 14047 and CI 13987. These three sources have shown excellent stable resistance in international leaf rust nurseries.

Foliar Disease Loss Studies. Yield tests at Pullman and Walla Walla were conducted in 1978 wherein one-half of each plot was protected by a fungicide that gives good control to stripe rust and partial control to leaf rust. By comparing the yields of the fungicide-treated plots to the untreated plots, we were able to measure the relative protection level afforded by the sources of resistance we are currently using in our program.

Particularly useful sources for stripe rust resistance included Webster, *Triticum spelta,* Ibis, Minister, Chinese 2*/*Agropyron elongatum*/Pawnee, CI 13749/Druchamp, Sel. 1/Viking, Cleo and Sel. 1/Clarkan. Sources that usually gave only mediocre control included Spaldings Prolific, Professor Delos, Sel. 1/Purkof, Noel and Little Joss.

These studies are underway again this year but it appears remote that rust diseases will cause appreciable damage to the 1979 crop.

GENETIC STUDIES ON TOLERANCE TO *CERCOSPORELLA* FOOT ROT

R. E. Allan, G. W. Bruehl, J. A. Pritchett
M. L. Baldridge and M. A. Patterson
USDA, SEA, AR and WARC

This year we are testing the level of tolerance to *Cercosporella* foot rot of some 1270 varieties, advanced and early generation selections. The major portion of this test involves the screening of 950 F_4 lines of crosses of Hyslop, Cerco and Sel. 101 to three French selections that have foot rot tolerance derived from a relative of Goat Grass, *Aegilops ventricosa.* Many of these lines were severely damaged by cold temperature but enough of them have survived that we should get some idea as to the genetic control of foot rot tolerance of these French selections. We are hopeful that we will find some suitable agronomic types among the material.

Last year we had an excellent foot rot test. Among 400 advanced lines of five crosses, we identified 45 that had tolerance similar to Cerco. These lines have been reselected and will go back into foot rot tests this fall. Crosses involving the tolerant sources of Viking, Druchamp, Svalof 814, N98 and Cerco suggest that there is considerable genetic diversity for foot rot tolerance. Tolerance comparable to Viking was recovered among five semidwarf types that yielded 97 to 102 bu/A in foot rot inoculated plots.

In five of the eight populations tested, we found that lines which were usually damaged the least by foot rot also lacked high yield potential. This finding re-enforces our argument that the best way to measure tolerance to foot rot is to measure yield loss. We did find that empty heads, lodging and reduced plant height also related to yield obtained under foot rot inoculated conditions. However, none of these traits predicted tolerance as accurately as actual yield loss data.

CERCOSPORELLA FOOT ROT OR STRAWBREAKER

G. W. Bruehl, R. Machtmes, T. Murray

Major effort for over 10 years has gone into the task of developing wheats resistant to this disease. Pathologists have developed inoculation techniques and identified sources of resistance. Breeders have screened large nurseries of lodged, tangled, blighted wheats for years. Dr. Peterson produced Cerco, a semi-dwarf of value as a parent. He may now have wheats of commercial potential with good resistance. But the cost of present methods, in time and money, is high. A cheaper, less laborious method would have great cumulative value for years to come. A major hope of the pathologists is to devise a truly efficient system.

For three years we worked on a greenhouse technique to screen wheats in the seedling stage for resistance. We are now convinced that this method is impractical. We now hope to devise a method to select individual resistant wheat plants in the first segregating population in the field. We may have done so at Puyallup last year, but this needs verification.

In the past the fungus was grown on oat kernels. The oat kernels were spread in the disease nursery in the fall. During cool moist weather spores would splash from the oat kernels to the wheat. We are now experimenting with spraying the wheat directly with spores. In this way all tillers could be infected simultaneously, rather than sporadically as by spores splashed about from the oat inoculum. This could increase the precision of the tests.

Benlate reduced losses from foot rot, both by increasing yield and by reducing lodging on many farms last year. The frequent rains in spring favored both the disease and the fungicide. We recommend applying Benlate in late winter or early spring. Some years ago we applied Benlate in the fall with success, but winter kill of Sprague wheat was increased when it was sprayed with Benlate in late October this past winter west of Mansfield.

This year Mertect and Benlate are being compared on Stephens winter wheat on the Paul Hofner Ranch near Waitsburg. Mertect and Benlate are similar fungicides but they are not identical.

WINTER DISEASES OF WHEAT AND BARLEY

G. W. Bruehl, R. Machtmes, P. Lipps, D. Gertenbach

The drought in the Douglas-Okanogan County area continued through the winter of 1978-1979, with insufficient snow for snow mold development. For three consecutive seasons we will have no meaningful data in this area, either for disease or for yields, unless rains start soon. It now appears that we should select the most promising lines as possible replacements of Sprague and proceed to advance them in the variety development program. We cannot delay forever.

The snow rot disease caused by *Pythium* spp. when water flows beneath snow and ice developed in a plot on the Goldmark Ranch in Okanogan county. This disease rots the crowns and leaves without damaging the roots. Little or no recovery occurs and it is more severe on early-seeded (large) than on late-seeded (small) wheat. We discovered no high level of resistance, and, because the disease is restricted to low areas where water runs or collects, we do not recommend efforts to develop resistance to this disease.

In the 1977-1978 winter *Typhula incarnata* killed half of the plants of Kamiak and Luther barley on the Kramer Ranch near Harrington. The winter was mild and moist at this site; cold did not kill the barley, the fungus did. If winter barley is to expand significantly in Washington, it must not only be more hardy but it must also have some resistance to winter fungi. In cooperation with Dr. R. A. Nilan, we seeded the entire world winter barley collection on the Kramer Ranch in September, 1978. Sufficient snow protected the barley from severe cold damage, and about 2% of the barleys have enough hardiness to warrant further testing, both for cold and for the fungi. We plan to continue at least one more season with the winter barley effort.

PLANT STUNTING AND ROOT ROT CAUSED BY PYTHIUM

R. J. Cook

Results with soil fumigation in eastern Washington since 1974 have revealed the existence of a heretofore unrecognized disease of wheat in this area caused by a soilborne fungus, *Pythium*. The symptoms are somewhat nondescript, being evident mainly as missing plants (often interpreted as seed skips), stunted plants, uneven height of tillers, and fewer tillers. The roots are only slightly discolored and may seem normal in appearance until compared with roots from fumigated soil. A major affect of the disease is destruction of the fine feeder roots on wheat, whereupon the plants may show phosphorous deficiency.

The disease affects both winter and spring wheat and is especially important on recropped wheat where seeding is late and into heavy residue. The disease is favored by cold wet soil and thus is most common in the low places in fields. The disease is especially important on no-till wheat and can account for much of stand establishment problems observed with this management system.

A fungicide is currently under study that controls the *Pythium* plant stunt and root rot. In-furrow applications with this material at seeding have greatly improved stands, tillering and plant vigor of wheat on no-till, and to some extent of wheat on tilled soil as well. Tests are also underway to determine whether the fungicide is effective as a seed-treatment. This work is primarily at the Palouse Conservation Field Station at Pullman.

TAKE-ALL OF SPRING AND WINTER WHEAT

R. J. Cook and E. Reis

Take-all, caused by the soilborne fungus known as *Gaeumannomyces graminis*, is the major foot rot of wheat under irrigation in the Columbia Basin. The disease is easily controlled by rotation of wheat with potatoes, corn, sugar beets, or other nonsusceptible crops. The disease occurs mainly when wheat is grown one or two consecutive years after wheat or barley. The disease is also severe in the second and sometimes already the first crop after alfalfa, in part because grasses in the alfalfa carry the fungus, and in part because alfalfa on a field makes the soil highly conducive to growth of the take-all fungus. The disease has been common in recent years on wheat under pivot irrigation.

Most of our research on take-all is conducted under irrigation at Lind. Some of our research is also conducted on the WSU Experiment Stations at Mt. Vernon, Puyallup, and Pullman.

Our research since 1968 has concentrated on how to control take-all with continuous wheat. The results to date can be summarized as follows:

1. Take-all develops best when the soil is continually moist to the very surface. To reduce take-all, irrigations should be as infrequent as possible, but with as much water applied as the soil can hold with each application.

2. Take-all is favored by no-till where all wheat residue is left as intact fragments full of fungus and on the soil surface in proximity to the crowns of the next crop. To reduce take-all, the fragments should be disked, rotovated, or buried, but not to such an extent that a serious erosion problem results.

3. Take-all is favored by nitrate nitrogen. The disease is also favored by phosphorous deficiencies. In some cases limited control has been obtained by use of ammonium forms of N where N-serve is used to keep the ammonium as ammonium. This method works best in acid soils such as those of western Washington and the Willamette Valley of Oregon. Some control has been obtained at Lind by use of phosphorous where P was somewhat deficient as revealed by a soil test.

4. Take-all tends to disappear from fields cropped repeatedly to wheat. This phenomenon, known as take-all decline, is due to a natural form of biological control. The responsible factor does not presist under alfalfa which may explain why alfalfa soils are conducive to take-all. Our research is now concentrating on learning the identity of the take-all decline factor.

WHEAT MANAGEMENT AND PRODUCTION

A. J. Ciha and Debra Metteer
USDA, SEA, AR

Objectives. The main objectives are to examine and identify varieties of winter wheat best suited for a particular tillage system, and to examine production and cultural practices for spring wheat and barley grown in Washington.

Ongoing Research. In the fall of 1978, experimental plots to examine the effects of tillage on winter wheat varieties were established at Dayton, Pullman, Palouse, Washington, and Gifford, Idaho. These plots included a selection of previously grown, presently grown, and experimental cultivars and lines of winter wheat. The tillage treatments used consisted of no-till, minimum, and conventional tillage.

For 1977-78, the highest yielding winter wheat varieties in conventional tillage were usually the highest yielders under no-till. Overall, the no-till seeding resulted in an average yield reduction of 13% from that of the conventional tillage seeding. When using a no-till system, one must consider previous weed problems and the previous crop grown. Seeding into a winter wheat or a winter-hardy spring grain stubble can result in problems associated with volunteer grain.

Production practices examined with the spring grains include seeding rate, planting date, and tillage. In 1978, a delay in planting from March 28 to April 11 and April 25 resulted in a yield reduction of 11 and 22%, respectively, for spring wheat and a yield reduction of 13 and 15%, respectively, for spring barley. The yield reductions observed in 1978 were very similar to the reductions observed in 1977. In 1978, there was a yield reduction with a low (0.6 bu/acre) seeding rate over that of medium (1.3 bu/acre) and a high (2.0 bu/acre) seeding rate while in 1977 seeding rate had no effect on yield.

In the typical summer fallow areas wind erosion can be reduced by maintaining a continuous ground cover on the soil. A continuous ground cover can be achieved by the use of annual cropping with no-tillage, which is now being examined at Lind and Harrington. At Lind in 1978, average yields for spring wheat and barley seeded on March 10 using no-tillage following a spring wheat crop in 1977 were 21 and 29 bushels per acre, respectively. Delaying seeding until March 27 resulted in yields of only 12 and 20 bushels per acre for the spring wheat and barley, respectively.

All of this work is continued in 1979.

TOPOGRAPHY AND SOIL VARIABILITY

A. R. Halvorson
Extension Soil Scientist
Washington State University

The fact that soil is highly variable is quite evident to anyone who harvests a field of grain. One of the most evident land features related to variability in yield is topography–slope of the land. What soil characteristics are associated with topography that can produce a difference in yield?

1. Soil Fertility Variable.

   a. Erosion on hill *tops and ridges* will have removed the nutrient enriched top soil. The exposed sub soil is deficient in nitrogen, phosphorus and sulfur (and possibly molybdenum for legume crops).

   b. On the broad *mid slope areas* where little erosion has occurred, the production capacity is generally proportional to the moisture and nitrogen supply.

   c. *Bottomland* portions of the field will vary in yield from better than that on the mid slope area to lower than the mid slope area. It can be better because it may receive additional moisture (runoff) from adjoining areas and possibly some nitrogen with the water. Also, soils in the low lying areas generally have a higher organic matter content–thus they have the potential for releasing more available nitrogen.

      Yields may be lower because of excessive amounts of water–saturated soil with consequent loss of nitrogen by leaching or de-nitrification. A low lying area may be more productive one year, less productive the next, all depending on whether the moisture was excessive or whether it received just enough extra to eliminate that late season shortage of moisture and nitrogen.

2. Soil Compaction Variable.

   a. Eroded areas may have more compact soil than noneroded areas because:

      The exposed sub soil having less organic matter is more easily conpacted than adjoining soil areas which are not eroded. Organic matter helps resist compaction.

      In some areas of the Palouse, there is naturally a more dense zone of soil at a depth of 10-20 inches below the original soil surface. In some areas sufficient erosion has occurred to make this zone the current "top soil." While these areas were not the most productive even in their original state, they are even less productive when this dense zone becomes the "top soil."

   b. Compaction (from farming operations) can occur in any portion of the field but it tends to be greater:

      Where erosion has occurred (because there is less organic matter).

      Where the soils remain wet longer than the main part of the field. Soils are most subject to compaction from farming operations when soil moisture is near field capacity. Since the starting of field operations is likely determined when the major portion of the field is ready, there could be some areas in the field at a vulnerable soil moisture level. Very often this will be in the lower lying areas.

Where there is extra traffic—temporary roadway, at field corners where turns are made or when plowing around the field.

3. Soil Moisture Variable.

a. The rate at which soil can absorb (take in) rain or melting snow is related to pore space—size and number. This in turn is related to:

Soil texture—most dry land wheat soils are in the silt loam textural class. Under the best of conditions, the water intake rate would be medium. Compaction can greatly slow the intake rate.

Amount of organic matter—organic matter tends to make the soil more open and porous. Generally the more organic matter, the better the water intake rate.

Compaction—compaction is simply a matter of more soil in the same space at the expense of having squeezed out the pore space—particularly the larger pores. Fewer pores and smaller ones results in slower water intake.

b. The amount of moisture in the soil at any one point in the field can also be associated with the amount of runoff water that may have collected in a particular area of the field. Sometimes there is a layer in the soil profile that restricts continued downward movement of water. These restrictive layers generally slope downhill and will cause a downhill subsoil movement of water. Some low lying areas remain wet a long time after others have drained and have become normal, because the subsoil inflow of water keeps replacing that lost by evaporation.

SOIL FERTILITY MANAGEMENT FIELD TRIALS FOR WHEAT PRODUCTION

Fred Koehler, Marvin Fischer, Emmett Field, and Raymond Meyer

There are 32 field experiments concerning soil fertility management for wheat production being conducted in 1979. These are distributed throughout the wheat producing area of eastern Washington from Asotin to Waterville (see map and lists of grower cooperators for locations).

A comparison of no-till with conventional tillage under different fertility treatments with both winter and spring wheat is being conducted at three locations. At other sites source and rate of nitrogen application under a no-till system of production are being studied. The use of a nitrification inhibitor with fall applied fertilizer is being studied at a number of sites.

The use of spring top dressing with nitrogen for winter wheat is being studied. Treatments include rate and source of nitrogen as well as the use of sulfur in addition to nitrogen.

At Spillman Farm there is a long term study on the effect of soil acidity on wheat and pea production. Three levels of soil acidity have been established. Superimposed on these treatments are sources of nitrogen (ammonium N versus nitrate N) and the use of trace elements. To date there has been no effect on wheat yields.

Other experiments include further studies on nitrogen sources and rates for winter wheat, source and rate of phosphorus fertilizer, use of sulfur, time and methods of using dry fertilizer in a wheat fallow rotation, rates and sources of nitrogen and sulfur for spring grain, and sources and methods of application of various kinds of fertilizers with a no-till system.

In 1978 there were several responses to spring top dressing of winter wheat. All nitrogen fertilizer materials gave similar yield responses. In the no-till experiments, where moisture was limiting, no-till resulted in higher yields than did conventional tillage. In other experiments where moisture supply did not limit yields, the highest yields were produced with conventional tillage. In the higher rainfall area, weed problems were more severe than in earlier years, presumably because of heavier than normal late spring and summer rainfall. Band placement of nitrogen and sulfur fertilizer for spring wheat with no-till was much more effective than was surface broadcasting these materials.

WEED CONTROL FOR SPRING CEREAL PRODUCTION UNDER ZERO TILLAGE IN THE INTERMEDIATE RAINFALL ZONE

Roland Schirman
USDA, Science and Education Administration, Agricultural Research

Production of spring grain in the 14 to 16 inch rainfall zone, either annually or in a three year rotation (winter wheat-spring grain-fallow), has been proposed as a way to reduce the erosion potential of fields of this area. Marginal yields of spring grain are often obtained under conventional tillage systems.

Trials in 1977 and 1978 demonstrated that, under a no-till system, improved yields could be attained because of timely seeding and maximum utilization of late spring rains. Yields of Fielder wheat and Steptoe barley were 47 bu/A and 1.5 ton/A at Dusty and 33 bu/A and 1.1 ton/A at Ewan.

This management system may require up to three applications of herbicide. A preplant, contact material, such as glyphosate (Roundup), is needed to eliminate volunteer and winter weeds. Additional products are required to control broadleaf and grassy weeds that emerge subsequent to planting. Herbicides, such as bromoxynil (Buctryl or Bomanil), metribuzin (Lexon or Sencor), diclofop (Hoelon), and difenzoquat (Avenge), have performed well.

Trials have been established at four locations in 1979 to evaluate other herbicides and hopefully establish guidelines to predict anticipated yield based on available moisture measured about March 1.

INTEGRATION OF HERBICIDES AND TILLAGE IN FALLOW

R. D. Schirman and D. C. Thill*
USDA, Science and Education Administration, Agricultural Research

Other workers have demonstrated that optimum moisture storage and reduced erosion is attained if crop residues are left undisturbed until late spring. We have conducted trials the past several years using selected herbicides to retard weed growth during the winter and early spring months of the fallow period and compare the total tillage requirement between systems initiated on various dates. Yields in 1978 (drought in 1977 fallow) showed no difference between dates of initial tillage if weeds were suppressed during the winter period. With the delay of initial tillage until May, three rod weedings were eliminated.

Herbicides that alone or in combination continue to look promising for this application include atrazine (AAtrex), cyanazine (Bladex), glyphosate (Roundup), metribuzin (Lexone or Sencor), and paraquat (Ortho Paraquat).

To insure consistent, timely emergence, we feel some tillage is needed under Washington conditions rather than a true zero tillage chemical fallow.

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*Presently with PPG Industries

INTERACTION OF TILLAGE SYSTEMS AND CROP ROTATION ON WEED PROBLEMS UNDER ANNUAL CROPPING

Roland Schirman
USDA, Science and Education Administration, Agricultural Research

Long term studies comparing annual fall moldboard plowing to rough tillage and zero till under various cropping sequences are being continued. Our observations lead to the following generalizations:

1) Presently available herbicides do not have adequate selectivity to allow use of continuous winter cereal production under zero tillage if grassy winter annual weeds, such as goat grass or downy brome (cheat grass), are present.

2) Acceptable weed control and crop yield can be obtained under all tillage systems when alternate spring-fall cropping and proper herbicides are used.

3) Predominance of a given weed can be related to the tillage system used but changes from year to year, depending on environmental factors. As an example, in a wheat pea rotation, some years wild oat has been a severe problem only in the moldboard plowing tillage, while other years it has been extreme on the zero tilled and relatively insignificant on the moldboard plowed plot.

4) Weed species that are most difficult to control under zero and reduced tillage are goat grass, catchweed bedstraw and downy brome (cheat grass).

EFFECT OF SUB-SURFACE FERTILIZER PLACEMENT ON GRASS WEED GERMINATION AND GROWTH

L. A. Morrow, V. L. Cochran and R. D. Schirman

Nitrogen fertilizer was applied at 0, 60, 120, or 180 lb/A either surface broadcast or placed about 3 inches below Daws winter wheat seed to determine the effect of fertilizer placement on grass weed growth in three types of tillage. Tillages included: 1) plowing and conventional preparation of the seedbed, 2) shallow incorporation of residue, and 3) seeding into standing stubble. Downy brome and jointed goatgrass were seeded at a rate of 20 seeds/sq ft to assure a moderate to dense stand of grass weeds. Early observations indicate the surface applied nitrogen stimulated germination and growth of grass weeds. Shallow incorporation of crop residue also appeared to reduce soil erosion compared to plowing and conventional preparation of the seedbed.

GENETIC ASPECTS OF WHEAT ADAPTATION TO CONSERVATION TILLAGE SYSTEMS

R. E. Allan, J. A. Pritchett, M. L. Baldridge and M. A. Patterson
USDA, SEA, AR

This year we have a test on Spillman Farm that contains 31 isolines, and 49 wheat selections sown in a split-plot arrangement on summer fallow, no-till/pea residue, no-till/barley residue and minimum-till/barley residue (Glencoe Soilsaver). It is already apparent that there are significant differences in plant development among the four management variables. Generally, the no-till pea residue plots look the best. The summer fallow plots emerged irratically last fall and the stands are thin. Stand was also a problem in the no-till and minimum-till plots on barley stubble. A major contributing factor was rodent damage in these plots. Apparently the barley residue offered mice enough protection that they were able to severely damage the stands.

We obtained some interesting results last year at Colton with no-till and conventionally tilled plots sown on barley and pea residue. Rather than finding a specific plant type adapted to the conservation tillage systems, we found an array of plant types did well. Isolines of several plant height levels placed in seven genetic backgrounds showed no single height level was best adapted to no-till. Adapted types included club wheats, semidwarfs and hard red and soft white winters. Sister lines of two crosses indicated that medium early lines were the most productive for no-till after barley. Generally, no-till after barley and pea residue reduced yields by 9 to 13%, yet the yields were not significantly reduced in 14 of 36 comparisons. In 12 of 30 comparisons we found a significant negative correlation between inherent yield potential and the yield difference between tilled and no-tilled plots. In other words, in some populations the lines that did best under no-till conditions lacked inherent yield potential. Fortunately, there are exceptions to this relationship among most populations that were tested.

No-till caused a variable effect on plant height. When no-tilled and tilled plots were compared, we noted that plant height was generally increased with no-till after pea stubble but decreased after barley stubble. This resulted in an increase in lodging under no-till for varieties which have weak straw such as McDermid, Luke and Paha.

No-till had a variable effect on test weight, increasing it for some populations and decreasing it in others, but usually caused no difference compared to the tilled treatment. No-till usually did not significantly change tillering ability except for 4 of 26 comparisons where tillering was reduced in three and increased in one.

One fact is certain, it will take us several years of intensive testing at several locations on various crop residues before we can expect to identify significant trends as to which plant genotypes and populations are best adapted to conservation tillage systems.

RUNOFF AND EROSION PREDICTION AND CONTROL

D. K. McCool, K. E. Saxton and R. I. Papendick
USDA, Science and Education Administration, Agricultural Research

A continuing effort of the SEA-AR Land Management and Water Conservation Research Unit at Pullman is to adapt the Universal Soil Loss Equation (USLE) to the region for use as a soil and crop management planning tool and to predict the effect of changes in management on soil erosion and water quality. The USLE uses factors for rainfall and runoff, soil type, slope length and steepness, crop management, and erosion control practice in predicting long term average soil losses in tons per acre. The first generation adaptation was developed in 1974 and is currently being used by the Soil Conservation Service in applicable portions of Idaho, Oregon, and Washington. The equation has recently assumed more importance as the only tool available to assess the effect on soil erosion of the Best Management Practices developed under Section 208 of the Public Law 92-500.

An erosion survey across Whitman and Latah counties and a more localized study to determine the effect on erosion of slope length and steepness are part of the USLE effort. Soil loss is measured with the rill meter, a 6-foot wide device that photographically records soil loss. The erosion survey had been conducted for three seasons and the slope length and steepness study for four seasons prior to the 1976/77 erosion season when no erosion occurred. Results indicate that slope steepness has much less effect on erosion here than in the Midwest.

Runoff plot studies to compare the effect of land treatment on runoff, soil loss, and water quality have been installed on and near the Palouse Conservation Field Station (PCFS) and near Rockford and Fairfield on cooperators' land. The PCFS study is in cooperation with the Agricultural Engineering and Agronomy and Soils Departments of WSU. The Rockford study is at the request of the Intermountain Grass Growers Association and the Washington Department of Ecology to help assess total effects of alternatives to the grass seed field burning practice.

The plot studies at the Palouse Conservation Field Station include such treatments as conventionally seeded annually cropped winter wheat, a winter wheat/summer fallow rotation, no-till winter wheat seeding, no-till winter wheat seeding with vertical slotted mulch, and various rough tillages and standing stubble in preparation for spring crops. The vertical mulch is a new technique being tested to maintain water infiltration even under frozen ground conditions. Most of the studies were started in the fall of 1976. Because of the drought and lack of runoff no erosion occurred in that season. The 1977/78 runoff season was also influenced by the 1976/77 drought in that soil moisture was still quite low on all treatments and crop yield and residue production was also quite low. The result was that the only treatments to yield significant runoff were the no-till seedings. This is believed to be primarily the result of the low amounts of surface residue available for protection. The 1978/79 runoff season was dominated by the extended period of deep soil freezing under a heavy snow cover. The soil remained frozen until the snow cover melted. Shortly after the soil became bare and started to thaw from the surface, a rainstorm caused severe erosion to the finely tilled plots. Total season soil loss on winter wheat after summer fallow was over 15 tons per acre with runoff of 5.5 inches. Soil loss on recropped wheat was only 2.5 tons per acre with runoff of 4.3 inches. Soil loss from no-till seeded plots was only 0.5 tons per acre with runoff of 4.5 inches.

Results from the Rockford study indicate critical periods for erosion in bluegrass seed production are the year of establishment and the season immediately following sod plow-out, because of the excess tillage required to break up the sod. Established bluegrass usually produces moderate to high volumes of sediment-free runoff. Most of the results of this study can be attributed to tillage and/or soil moisture effects.

WATER USE-EFFICIENCY OF TILLED AND NO-TILLED WINTER WHEAT WITH SUPPLEMENTAL IRRIGATION AT LIND

V. L. Cochran, R. D. Schirman and D. C. Thill*
USDA, Science and Education Administration, Agricultural Research

Summer fallow practices in the Pacific Northwest store and conserve water more efficiently than any other place in the world. Still, 50% of the rainfall is lost to evapotranspiration without benefit to the crop. Previous work at Lind, using supplemental irrigation on recrop to accomplish deep movement of fertilizer N, resulting in higher winter wheat yields than was anticipated for the amount of water applied plus that received as rainfall. This suggests a potential for improved overall water use-efficiency by fall supplemental irrigation of recrop, thus avoiding the over-summer loss of water to evaporation during fallow. Further improvement in water use might be attained by no-till practices, as has been experienced in other parts of the country. For these reasons, an experiment was set up in 1977 to compare supplemental irrigation on recrop winter wheat with and without tillage. Three dates of irrigation were selected. Four inches of water was applied on August 15, September 1, and September 15 to a new site on each date. Planting followed the irrigation by two weeks with the exception of the August 15 irrigation which was planted at the same time as that irrigated on September 1. A John Deere HZ drill was used for both the tilled and no-till planting.

Soil water was determined on April 1, 1978, and the early irrigation had 1 inch less stored water than the corresponding tillage treatment irrigated on September 1. For both irrigation dates, the tillage treatment had approximately 1 inch less water than the no-till treatment seeded. The late irrigation (September 15) had the same amount of water as did the no-till seeding irrigated September 1, with no difference between tillage treatments. Thus, water storage can be increased by delaying irrigation or by no-till seeding. Adequate stands were established with all treatments; however, the direct seeded treatments did not tiller well and showed P deficiency even though the soil test indicated adequate P levels. Slight P deficiency symptoms occurred in the tilled planting of the late irrigation also. The tilled early-planted treatment, irrigated on September 1, yielded the highest (53 bu/A) compared to the direct seeded treatment (42 bu/A). The tillage treatments for both the other irrigation dates yielded 44 bu/A versus 37 bu/A for the no-till seeded treatments.

Additionally, on an adjacent site, the weed control and crop tolerance of various herbicides in supplemental irrigated conventional and no-till winter wheat was evaluated. Herbicides tested at various stages of crop and weed development included diclofop (Hoelon), trifluralin (Treflan), bomoxynil + MCPA (Bronate), metribuzin (Lexone or Sencor), Linuron (Lorox), and R-40244. Weed infestations in the plot area were slight; thus, weed control data for the 1977-78 crop year were limited. In the no-till plots all herbicide treatments, except bromoxynil + MCPA and metribuzin, applied post emergent (PE), reduced grain yields. Yield reductions ranged from 5 to 25% of the untreated check. In the conventional tilled plots, only bomoxynil + MCPA (PE) metribuzin + linuron (pre-plant) and trifluralin (pre-irrigation) did not reduce grain yield. Yield reductions ranged from 5 to 23% of the untreated check. Both experiments were repeated in the fall of 1978, but winter killed.

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*Presently with PPG Industries

A current project of the Land Management and Water Conservation Research Unit in cooperation with the Agricultural Engineering Department of the University of Idaho is to evaluate the effect on soil erosion and water quality of the Five Point Program of the Latah Soil Conservation District. The Five Point Program consists of the following elements: (1) restricted summer fallow, (2) minimum tillage, (3) contour seeding, (4) divided slope farming, and (5) seeding critical areas. The study was undertaken as part of the Section 208 area-wide waste treatment planning effort established by Public Law 92-500, Water Pollution Control Act Amendments of 1972. The study includes runoff plots to evaluate the effect on runoff and soil loss of such treatments as divided slope and minimum tillage, rill meter studies to evaluate more conventional treatments, and downstream sampling sites to attempt to relate water quality to upland treatment. The project was started in the fall of 1976, but because of the drought, little or no data were collected in 1976/77. The only visible erosion occurred on fields planted to winter wheat after peas. The 1977/78 erosion season was more typical with several runoff events starting in late November. Again the winter wheat seeded into pea residues suffered the largest soil loss and produced the largest amount of sediment moving past the downstream gaging station. There was no winter wheat following summer fallow in the study area. The 1978/79 results are not yet available.

The 27 square mile Missouri Flat Creek Watershed is the site of a sediment transport study to determine the total amount of sediment transport from the watershed, the daily and seasonal variation in water quality, and the delivery ratio, or the proportion of soil eroded from uplands and stream banks that reaches the South Fork of the Palouse River.

EQUIPMENT FOR FERTILIZER PLACEMENT AND NO-TILL

G. M. Hyde, D. M. Payton, J. B. Simpson
Agricultural Engineering Department
Washington State University

In the fall of 1977, several sets of plots in three residue types were seeded in three basic experiments: the opener design experiment, the drill survey experiment, and the fertilizer placement experiment. All plots received 101 lb. of N per acre, 41 lb. of P, and 6 lb. of S. The fall-seeded plots were planted with 60 lb. of McDermid seed per acre.

Two sets of spring-wheat fertilizer placement plots were also seeded in the spring of 1978 in wheat-residue with the same fertilizer rates and using Fielder seed at 90 lb/acre.

Table 1 shows the results of these experiments in terms for yield per acre.

Table 1. WSU Yield Results, 1977-1978 Plots

Fall Seeded

Opener Design Expt.			Drill Survey Expt.	
	Residue			
Opener	Wheat or Barley	Pea	Drill	Yield
JD/HZ	a* 56 bu/A	c* 65 bu/A	Ag Engr.	a* 64 bu/A
Double disk	b 52	c 70	JD Power Seeder	a 60
Deep till	a 55	d 59	USDA II	ab 58
			Mod. Midland	ab 56
			Bettinson 3-D	ab 56
			JDHZ	b 46

*Treatments with same letter are not significantly different at the 5% level of significance.

FERTILIZER PLACEMENT EXPERIMENT

	Fall Seeded		Spring Seeded on
	Wheat Residue	Pea Residue	Barley & Wheat Residue
Placed	65 bu/A	55 bu/A	44 bu/A
Broadcast	55	58	33
Significance Level	3.0%	24%	0.001%

Opener Design

On a fairly heavy wheat and barley residue, hoe openers gave significantly better yields than the double-disk openers. However, on pea residue, the double disk and H-Z openers were significantly better than the deep till opener. These results are for fall seeding with broadcast fertilizer and starter fertilizer placed with the seed.

Drill Survey

In the drill survey experiment, differences in yield among all the drills were not large; however, the Agricultural Engineering drill (with the deep hoe opener placing fertilizer below the seed and double disk seed opener behind the packer wheel) and the John Deere power seeder were significantly better than the John Deere H-Z. The latter two were with broadcast fertilizer.

Fertilizer Placement

For fall seeding in the fertilizer placement experiment, the results show that in wheat residue, placed fertilizer has a significant yield advantage over broadcast fertilizer. However, in the pea residue there is no significant difference between the two fertilizer application methods. In spring seeding, however, there was a very highly significant advantage to placing the fertilizer below the seed as opposed to broadcasting it.

It was also evident in the spring wheat seeding that the late-season wild oat population was considerably less where the ammonium nitrate-sulfate fertilizer (ANS) was placed below the seed as opposed to where it was broadcast (the plots had all been sprayed with Avenge® early in the summer). These results are confirmed by laboratory data from other researchers showing that ANS helps to break the dormancy of hard wild-oat seeds. The protein content of the wheat from the placed fertilizer plots was significantly higher (.4%) than that of the wheat from the broadcast fertilizer plots.

Preliminary greenhouse studies show that, if the fertilizer is to be placed below the seed, it should be at least 2 inches below the seed for ammonium nitrate at 100 lb. of N per acre on 16-inch row spacing under moderate moisture conditions. Field studies show that placing ANS at 1-1/2 inch below the seed under wet conditions is safe but can result in seedling damage under the dry conditions of the fall of 1978.

Future Plans

Current and future work includes evaluation of the fall of 1978 plantings on six locations and four residue types with drill survey, opener design and fertilizer placement experiments as before. Also, barley after barley plots, conventional versus no-till, starter fertilizer with versus below the seed, and standing versus rolled stubble no-till comparisons will be made. Erosion plots were planted in cooperation with Don McCool, of the USDA, to evaluate the erosion control potential of the cultural practice. Also energy instrumentation is being assembled for evaluating energy requirements of the various cultural practices.

Spring, 1979 plantings include two no-till experiments at the USDA Conservation Farm. The first is in cooperation with crop, weed, and soil scientists. This experiment compares row spacings, fertilizer placement, two types of herbicides (pre-emerge, post-emerge, and un-sprayed check), and a tilled check. The main fertilizer was ammonium nitrate, the starter fertilizer was 0-18-0-12, and the total N applied was 80 lb/acre. The plots are on a north slope in residue from a 90 + bu/acre winter wheat crop. Seed was 90 lb/acre of Fielder spring wheat.

The second experiment is on a south slope in spring wheat residue with 90 lb/acre of Fielder seed. This experiment compares a tilled check with 6 fertilizer-seed opener combinations as shown in Table 2.

Table 2. AgE Conservation Farm Experiment

Code	Drill Name	Fertilizer Opener	Seed Opener
A	Ag Engineering	Standard double disk (front)	Standard double disk (rear)
B	Ag Engineering	Modified HZ hoe	Modified HZ hoe
C	Ag Engineering	Johnson hoe	Johnson hoe
D	Ag Engineering	Modified HZ hoe	Standard double disk (rear)
E	USDA II	Broadcast	Offset double disk
F	Koehler	Fischer hoe	Standard double disk

The main fertilizer was ANS at 72 lb of N per acre; the starter fertilizer was 11-55-0 at 8 lb of N per acre. All plots were 16-inch row spacing except the Koehler drill which was 8-inch spacing. Drills A, D, and E placed the starter fertilizer with the seed. The others placed it below the seed.

In addition to these experiments, 20 acres of spring wheat plots were planted near St. John in which the following comparisons were made:

1. Starter fertilizer with vs. below the seed,

2. ANS vs. UAS main fertilizer,

3. Johnson hoe opener for seed and fertilizer vs. that opener for fertilizer and a standard double disk opener for seed.

A tilled check was also included. The wheat variety again was Fielder.

CROP RESIDUE MANAGEMENT IN NO-TILL WINTER WHEAT

V. L. Cochran, L. F. Elliott, R. I. Papendick, and C. L. Canode
USDA, Science and Education Administration, Agricultural Research

Direct Planting into Wheat Stubble

Direct drilling crops into cereal residues effectively decreases soil erosion, but often crop yields are reduced. This is particularly true where large amounts of crop residues remain on the surface, such as in the center of the combine path or in low areas of the field. The plants in these areas are often chlorotic, unthrifty and stunted. The problem seems related to the production of toxins during straw decomposition. After a cool, wet period of three or more days, chemicals (toxins) which are very inhibitory to wheat plant root growth can be extracted from the decomposing residues with water. They disappear when the residue dries or the weather warms. The toxin(s) is rapidly deactivated in the soil, thus the plant must be in close contact with the decomposing residue to be injured.

Plant injury occurs at two growth stages; when the seedling is emerging and contacts crop residue pushed into the seed furrow; and when the secondary roots are forming. Where the plant emerges through a residue mat, it sets a high crown. Often the high crown is set in the residue mat so the secondary roots are in intimate contact with the residue before entering the soil.

Grain drills designed to move the crop residue away from the seed row would avoid placing the seed in direct contact with the straw and would allow normal crown set. The effect of the toxin(s) on either the primary or secondary root would be minimized. A study evaluating the feasibility of moving the straw away from the seed row was initiated in the fall of 1976. However, the first season was unusually dry and no toxins were found and the drought masked damage to the crop due to heavy residues. The 1977-78 weather was ideal for the production of toxins, but crop residue levels were low because of the past year's drought. Early spring data indicated that, where winter wheat was directly planted into either spring or winter wheat stubble without moving the straw from the seed row, plant stands and tiller numbers were reduced by 20% compared to conventional tillage or direct seeding with straw moved from the seed row. However, no significant differences in grain yields were found between tilled or no-tilled treatments on either spring or winter wheat stubble. Yields were 90 bu/A or above on both sites for all treatments.

The dry fall of 1978 resulted in poor winter wheat emergence in the plots direct seeded into winter wheat stubble, but did not seriously reduce emergence of any of the seeding treatments into spring wheat stubble. Generally, in the plots direct seeded into winter wheat stubble, overwinter emergence in the straw away from the seed row treatment was much better than the straw in the seed row treatment. Further injury to the plants in direct contact with the heavy residues occurred shortly after application of bromoxynil and diuron mix to control broadleaf weeds (primarily mayweed). Where the straw was moved from the seed row, no visible injury occurred. All the plants showing injury were found to have high crowns with secondary roots in the straw mat. There was not visible herbicidal injury to winter wheat direct seeded into spring wheat stubble because the residue levels were much lower and the winter wheat plant did not set a high crown.

Direct Planting into Bluegrass Sod

Direct seeding of spring wheat into bluegrass sod killed with glyphosate has been successful in the Rockford, WA area. In three years of testing, direct seeding of spring wheat has outyielded conventional tillage into bluegrass sod by about 20%. In the fall, winter wheat is direct seeded into the spring wheat stubble and the killed bluegrass thatch. These yields have been good and additional herbicide has not been required on the second crop. This practice appears promising from a crop yield and energy and soil conservation standpoint.

VERTICAL MULCH

Keith E. Saxton

Improved water infiltration on our croplands will provide more water for crop production and significantly reduce erosion. Although we have some runoff and erosion every year, rain and snowmelt on frozen ground occasionally combine to give us our worst conditions.

Vertical mulch is a residue management technique in which straw is compacted into a trench some 2-3 inches wide by 8-10 inches deep and left to extend well above the soil surface. These continuous mulched slots will be approximately on the contour and spaced some 10-20 feet apart. Runoff very rapidly infiltrates these straw filled slots and flows to the bottom where it infiltrates even when the soil surface is frozen.

Vertical mulch will work best for minimum tilled wheat or standing stubble because the straw must be left well above the soil surface which is difficult to maintain if subsequent tillage is required prior to the runoff season. We will be testing the method on other applications such as grass fields and terrace channels.

During snowmelt and rains this spring (1979), when the soil had deep frost, almost all test plots had 4.5 to 6.0 inches of runoff with 2 to 15 tons per acre of erosion. No-till plots planted to winter wheat had 4.5 inches of runoff with about -.5 ton per acre erosion. Four adjacent no-till plots treated with vertical mulch averaged 0.4 inch of runoff and 0.02 tons per acre soil loss. Thus the vertical mulch increased infiltration about 4 inches (which may mean 20-30 bushels increased yield) and essentially stopped erosion in a year of significant frozen ground runoff.

We are now in the process of designing machinery to perform the vertical mulch tillage. The processes include cutting the trench, collecting the residue, and compacting the residue into the trench. The machine may become a combine attachment, a drill attachment, a single machine, or some other combination. Your comments and suggestions would be appreciated.

OILSEED CROPS

Steve Ullrich, Ken Morrison, Pat Reisenauer, and Michael Ramsay

A number of studies are being initiated this year on oilseed crops, primarily sunflowers. There has been a surge of interest in oilseed crops recently and these studies are aimed at determining the potential of the various crops, identifying high yielding varieties, and determining cultural practices that produce maximum yields.

Cultural studies are being conducted at the Dryland Research Unit near Lind, on the Marvin Repp farm at St. John, and at the Spillman Agronomy Farm near Pullman. These experiments include date of seeding, plant population, and varieties of various maturities. At Spillman, there are studies to determine the effect of seed size on yield and nutrient seed coating on seedling vigor. Yield trials include the national sunflower trial with 30 entries at Spillman and Lind and smaller trials at St. John, Deep Creek, and Garfield. Twelve Safflower varieties are being tested at Lind, St. John, and Pullman. A small trial including varieties of flax, mustard, spring rape, and crambe is planted at the Spillman Agronomy Farm.

1979 Plot Locations

Dryland Research Unit near Lind	Sunflower variety and culture
	Safflower variety
St. John–8 mi. S.–Marvin Repp	Sunflower variety and culture
	Safflower variety
Deep Creek	Sunflower variety
Garfield	Sunflower variety
Spillman Agronomy Farm near Pullman	Sunflower variety and culture
	Safflower variety
	Other oilseed variety

LENTIL RESEARCH 1978-1979

Van Wilson and Valerie Deusner
Science and Education Administration
U. S. Department of Agriculture
Pullman, WA 99164

Research is continuing to evaluate both spring and winter hardy lentils for ability to withstand heat and cold stresses in the presence of soil pathogens, and to produce high seed yields with quality.

Field Studies:

Six spring type lentil breeding lines in advanced generations were grown in field plots in eastern Washington and northern Idaho. Seed yields and plant growth habits were compared to Chilean. At each location all test lines were characterized by upright growth habits and medium to large size seeds that are acceptable for machine harvest and commercial markets. Seedcoat damage resulting from combine harvesting generally did not cause seedcoats to separate from cotyledons.

At Pullman, Washington, Six advanced breeding lines were sown on May 19, 1978. The delayed planting date served to affect late flowering that reached maximum flower production between June 23 and July 3. At this time, lentil flowers were exposed to temperatures exceeding 80°F. Maximum seed yields in this experiment did not exceed 644 lb/A. It was interesting that one lentil line, previously identified as 511, has been among the highest seed yielding lentil lines for several years. This high yielding lentil, Redchief, has been approved for release on April 10, 1980.

Laboratory Studies:

Resistance to relatively high temperatures (80°F) during the flower and embryo development period is needed for increasing lentil seed yields. Research results show that lentil plants grown at temperatures between 65 and 75°F produce more seed per plant than plants grown from the same seed source at 75 and 80°F.

Heat resistant lentils appear to have their origin in small seeded non-commercial type varieties. Such seeds are used for parents in crosses with large seeded, commercial type lentils. The progeny plants from crosses first are grown in a greenhouse and later grown in a controlled growth chamber at 80°F. Segregating plants grown at 80°F show that about 8% of the populations develop flower pods and seeds while about 92% of the plants abort all flowers and pods. Heat screening tests indicate lentil lines can be developed with resistance to high temperature stress. The resistances appear to be genetically inherited.

Winter Hardy Lentils:

In 1976 and 1977 winter hardy lentils suffered severe plant and seed losses from drought and subsequent plant diseases. Only 27 breeding lines survived the winter and produced seed the following summer. One thousand eleven lines did not survive in 1977. In the fall of 1978 a winter hardy lentil nursery was planted at Pullman, Washington. Winter hardy WH 2040 germplasm was released.

Lentil Disease Survey 1978:

In early and late spring of 1978, surveys were made to determine the prevalence of diseased lentil plants. Isolations made in the laboratory indicated that no new pathogens infected lentils, and the incidence of infected plants was about the same as when isolated from plants grown in lentil fields during the past five years. *Pythium* spp. has been the fungus most frequently isolated from roots and stems of field grown lentils.

BREEDING, DISEASES AND CULTURE OF DRY PEAS

F. J. Muehlbauer and J. L. Coker
Science and Education Administration
U. S. Department of Agriculture

The objective of the dry pea breeding program is to develop high yielding disease- and insect-resistant varieties adapted to the Palouse region. Root diseases of peas caused by a complex of several organisms are the major reason poor pea yields have been common to the area. Most of our efforts the past few years have been in identifying resistant lines for use as parental material, hybridizing the resistant lines with commercial varieties, and screening the resulting populations for root rot-resistant segregants with good plant type and adaptability. Two green pea varieties, 'Garfield' and 'Tracer,' were released in 1976. Yield tests showed that Garfield, a large-seeded selection, out-yielded common Alaska by over 15%.

Garfield is resistant to *Fusarium* wilt race 1, is larger seeded, and has a longer vine habit when compared with most Alaska strains. The increase in plant height should improve harvesting ease, especially on ridges where lack of vine has been a problem. Garfield does not differ from Alaska in resistance to seed bleaching, powdery mildew, or mechanical damage. 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 the small-sieve checks. 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 should improve harvesting ease on the ridges where lack of vine has been a problem. Tracer tends to set triple pods at one or more of the reproductive nodes. The need for a small-sieve variety resistant to *Fusarium* wilt race 1 has been apparent since 1973 when it was determined that many small-sieve strains were susceptible. The release of Tracer should fill this need and also offer needed yield improvement.

The apparent resistance to pea root rot shown by Garfield and Tracer is an attribute that is responsible for their increased yields and also may be a factor in stabilizing dry pea production from one year to another and from location to location within a given year. We are hoping to identify breeding lines that show additional yield improvements over Garfield and Tracer in 1979, but more emphasis is now being placed on quality factors especially for resistance to seed bleaching and reconstitution. Pea lines WA510104 and WA510707 were in the yield class of Garfield and Tracer but more importantly, they represented earlier flowering, earlier maturing, and bleach resistant lines. All the lines tested were resistant to *Fusarium* wilt race 1, and had acceptable plant height. These breeding lines are being retested in 1979 along with a number of lines that have not been yield tested before.

WA510287 is a yellow pea selection that has a strong tendril habit that should improve lodging resistance. It was slightly smaller in seed size and slightly later blooming than Latah, but tends to be earlier maturing than Latah.

Pea seedborne mosaic virus has caused problems in our breeding program and is a potential serious threat to both dry peas and lentils. Because of the obvious threat this virus poses to the industry, we are incorporating resistance to the virus into the major pea varieties grown in the region. These varieties include five dry peas, ten freezer and canner peas, and one Austrian winter pea. We have made the fourth backcross and plan to release the resistant material in 1979. The virus-resistant derived varieties will be a means of preventing new virus outbreaks.

It has been known for some time that the virus will also attack lentils and is seedborne in that crop. Immunity to the virus was identified in the Plant Introduction collection, and is inherited as a single gene recessive. Incorporation of the resistance into commercial lentils is underway.

Preliminary selections are screened for resistance to powdery mildew at Pullman. Natural infection obtained by planting late in June have reached epidemic proportions at about bloom. Lines showing resistance are increased and evaluated for agronomic characteristics, especially yield, and will be used as parental material.

Lines with pea seed weevil-resistant parentage that showed resistance to *Fusarium* wilt race 1 are being evaluated in cooperation with the University of Idaho in 1979 for resistance to the insect. Hopefully, an agronomically acceptable line can be identified and used as a control measure for the insect or to effectively reduce the percentage of infestation. Work is also underway to control the pea leaf weevil through development of resistant varieties. Resistance or tolerance to the leaf weevil is associated with vigorous plant types with high leaf area.

TREES AND SHRUBS FOR DRY LAND PLANTING

Many species of trees and shrubs are included in the Station forestry project for farm-home landscaping and windbreaks. The first plantings are over 40 years old. The present testing program at Lind was started in 1928 by the Dry Land Research Unit and the Department of Forestry and Range Management, Washington State University. Plantings have been made at intervals since then. This Station planting is one of the best in the West for studying trees and shrubs adapted to dry land conditions.

Initial observation tests of woody species are carried on at the Soil Conservation Plant Materials Center at Pullman. Secondary tests are carried on cooperatively at experiment stations at Prosser and Lind, Washington, and Moro, Oregon. Station Circular 450, 1965, summarizes the results of these adaptation tests of trees and shrubs for the intermountain area of the Pacific Northwest.

A standard dry land windbreak planting consists of a minimum of three rows. When properly established, these give excellent protection from the winds. The windward row should be a tough, fast-growing shrub. Caragana is the best shrub for this purpose. Lilac is slower growing, but is hardy and makes a good dense hedge. Nanking cherry and blue leaf honeysuckle show good promise for the windward row. Where a taller shrub is desired, Russian-Olive appears to be the best adapted shrub, although a wild crab-apple shows promise.

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Whitman Co. Growers

Herbicides

American Hoechst
Monsanto Corp.
Rhodia Corp.
Mobay Corp.
American Cyanamid
CIBA - Geigy Chemicals
Shell Chemical Co.
Dow Chemical Co.
Velsicol Chemical Co.
Elanco Products Co.
Gulf Chemical Co.
Chevron Chemical Co.
Uni Royal Chemical Co.
Rohm and Haas Co.
Union Carbide
PPG Industries
BASF Wyandotte Co.
Thompson-Hayward Chemical Co.
Stauffer Chemical Co.
E. I. DuPont de Nemours

Cash Contributors

Chevron Chemical Co.
CIBA - Geigy Corp.
Inland Empire Golf Course Supt. Assn.
PPG Industries
Cominco American
Gustafson Inc.
Phillips Chemical
Palouse Producers Inc.
Palouse Rock Lake Cons. District
Northrup King and Co.
Western Plant Breeders
Vita - Grain Inc.
Norman Heitstuman
Palouse Soil and Water Conservation District
Stoller Chemical Co.
Great Western Malting Co.
Monsanto Agricultural Products Co.
Shell Development Co.
Malting Barley Improvement Assn.
Dow Chemical
Northwest Plant Food Assn.
Palouse Conservation District
American Hoechst Corp.
Diamond Shamrock Corp.
Stauffer Chemical Co.
Gulf Oil Chemical
Tennessee Valley Authority
Dekalb Seed Company

Farmer Cooperators

Variety and Disease Plots

Orin Anderson	Clyde
Joe Babbit	Pullman
Dale Bauermeister	Connell
Bayne Farms	Horse Heaven
Harold Beard	Mansfield
Bud Benedict	Asotin
Merrill Boyd	Pullman
Elwood Brown	Bickleton
Lawrence Buse	Waterville
Ken Clark	Bickleton
Harry Davis	Lamont
Richard Deffenbaugh	Kennewick
Jack DeWitt	Walla Walla
Diamond Spear Angus Ranch	Lamont
Don & Jim Druffel	Colton
Sanford Evans	Genesee, ID
Jim Ferrel	Walla Walla
Peter Goldmark	Okanogan
Harold Harmon	Waterville
Heitstuman Farms	Uniontown
Vern Hoffman	Rice
Ted Hornibrook	Goldendale
Don Jensen	Waterville
Robert Kramer	Harrington
Quentin Landreth	Espanola
Merle Ledgerwood	Pomeroy
Lehn Brothers	Farmington
Terry Ludeman	Waterville
Carl Mielke	Harrington
Woodrow Mills	St. John
Harold Naught	Bickleton
Don Ogle	Waterville
Orlund Ostheller	Fairfield
Kenneth Parks	Fairfield
D. E. Phillips	Lind
Jack Rodrigues	Wilbur
Bill Schmidtman	Waterville
Ernie Stueckle	Dusty
Harold Stueckle	Colfax
Mort Swanson	Palouse
Warren Talbot	Dayton
Don & John Wellsandt	Ritzville
Earl & Paul Williams	Reardan

Fertility, Tillage & Management

Lynn Ausman	Asotin
Joe Babbit	Pullman
Bahr Brothers	Wilbur
Clark Farms	Pullman
Paul Dashiell	Rockford
Dryland Research Unit	Lind
Elmer Easton	Harrington
Roy Eslick	Dayton
Fulfs Brothers	Pullman
Gordon Hamilton	St. John
Larry Heaton	Tekoa
Bob Heitstuman	Pomeroy
Herr Brothers	Ephrata
Lamar Homberg	Odessa
Bob Hutchens	Dayton
Tom Hyslop	Espanola
Bill Iverson & Sons	Odessa
William Jacky	Reardan
Maynard James	Wilson Creek
Jack Jenkins	Pullman
C. E. Larson	Rockford
Fred Lewis	Fairfield
Ron Lieby	Pullman
Mark Martin	Creston
Joe Myers & Sons	Colfax
Merwin Neace	Dayton
Don Ogle	Waterville
George Peringer	Belmont
Tom Petty	Asotin
Dan Plaster	Reardan
Al Proff	Waverly
Glen & Chris Ramsey	Freeman
Ralph Reinhardt	Fairfield
Tom Schultz	Reardan
Spokane Tribal Farms	Wellpinit
Mort Swanson	Palouse
Eric Thorn	Dayton
Wilford Thorn	Dayton
Larry Vincent	Gifford

Weed Control Experiments

Asotin County Highway	Clarkston
Bud Benedict	Asotin
Jean Bippes	Farmington
Doug Bruce	Farmington
Earl Clausen	Waverly
Mac Crow	Oakesdale
Roy Eslick	Dayton
Frances Fitzgerald	Clarkston
Gary Cluck	Touchet
Garfield County Highway	Pomeroy
Mike Gwinn	Pomeroy
Jim Hangen	Dayton
Roy Hostetler	Clarkston
Keith Mader	Palouse
Paul Mader	Pullman
Mereview Neace	Dayton
Ted Scheele	Waverly
Leigh Schultheis	Union Town
Ben Stueckle	Colfax
Morton Swanson	Palouse
James Titrick	Pomeroy
Turner Bros.	Dayton
Washington State Highway	Washtucna
WSU Farm	Pullman
Dean Whitman	Benge
Allan Wride	Garfield

LISTING OF COOPERATIVE PERSONNEL AND AREA OF ACTIVITY

Glenn Terrell . . . . President, Washington State University
J. S. Robins . . . . Dean, College of Agriculture
L. L. Boyd . . . . Director of Research, College of Agriculture
J. O. Young . . . . Director of Cooperative Extension
J. C. Engibous . . . . Chairman, Department of Agronomy and Soils

Cereal Breeding, Genetics, and Physiology

R. E. Allan, J. A. Pritchett, M. A. Patterson, USDA, Pullman . . . . Wheat Genetics
E. Donaldson, M. Nagamitsu, Dry Land Research Unit, Lind . . . . Wheat Breeding
D. W. George, J. Eldridge, B. Hunter, USDA, Pullman . . . . Winterhardiness
C. F. Konzak, M. A. Davis, M. Wilson, Pullman . . . . Wheat Breeding & Genetics
R. A. Nilan, A. Lejeune, C. E. Muir, Pullman . . . . Barley Breeding & Genetics
D. Henderson, Steve Hayward, USDA, Pullman . . . . Wheat Breeding
C. J. Peterson, USDA, Pullman . . . . Wheat Breeding
R. L. Warner, A. Kleinhofs, R. A. Nilan . . . . Cereal Evaluation Laboratory
Allan Ciha, D. Metteer, USDA, Pullman . . . . Wheat Mgmt. and Production
S. E. Brauen, Puyallup . . . . Varietal Testing
K. J. Morrison, P. E. Reisenauer, Pullman . . . . Varietal Testing
G. T. Vigue . . . . Plant Physiology

USDA Regional Wheat Quality Laboratory

G. L. Rubenthaler . . . . Research Cereal Chemist in Charge
Wheat Quality Laboratory
S. J. Kitterman . . . . Research Chemist
P. L. Finney . . . . Research Cereal Technician
H. C. Jeffers . . . . Experimental Miller
P. D. Anderson . . . . Experimental Baker
L. J. Gray . . . . Early Generation Testing
Mary Baldridge . . . . Agriculture Technician

Cereal Diseases

G. W. Bruehl, S. D. Wyatt, Pullman . . . . ; Cereal Viruses, Foot Rots and Other Diseases
R. J. Cook, Cooperative USDA, Pullman . . . . Root Rot Diseases
J. W. Hendrix, Pullman . . . . Leaf Rust Wheat Septoria
R. F. Line, Cooperative USDA, Pullman . . . . Flag Smut Control

Soil Testing

A. R. Halvorson, Pullman

Seed Testing

J. D. Maguire, Pullman

Breeding and Culture of Dry Peas

F. J. Muehlbauer, J. L. Coker, USDA, Pullman

Lentil Production

Van Wilson, Richard Short, USDA, Pullman

Cereal Crop Improvement

A. G. Law, Pullman
J. D. Maguire, Pullman
T. D. Wagner, Pullman

Spillman Farm Manager

G. F. Varner, Spillman
Agronomy Farm, Pullman

Fertility & Management

F. E. Koehler, Pullman
Marv Fischer, Pullman
R. Papendick, Pullman
V. L. Cochran, Pullman
E. T. Field, Pullman
C. F. Engle, Pullman
L. Elliott, Pullman
D. McCool, Pullman
K. Saxton, Pullman
R. Schirman, Pullman
D. Thill, Pullman
L. Morrow, Pullman