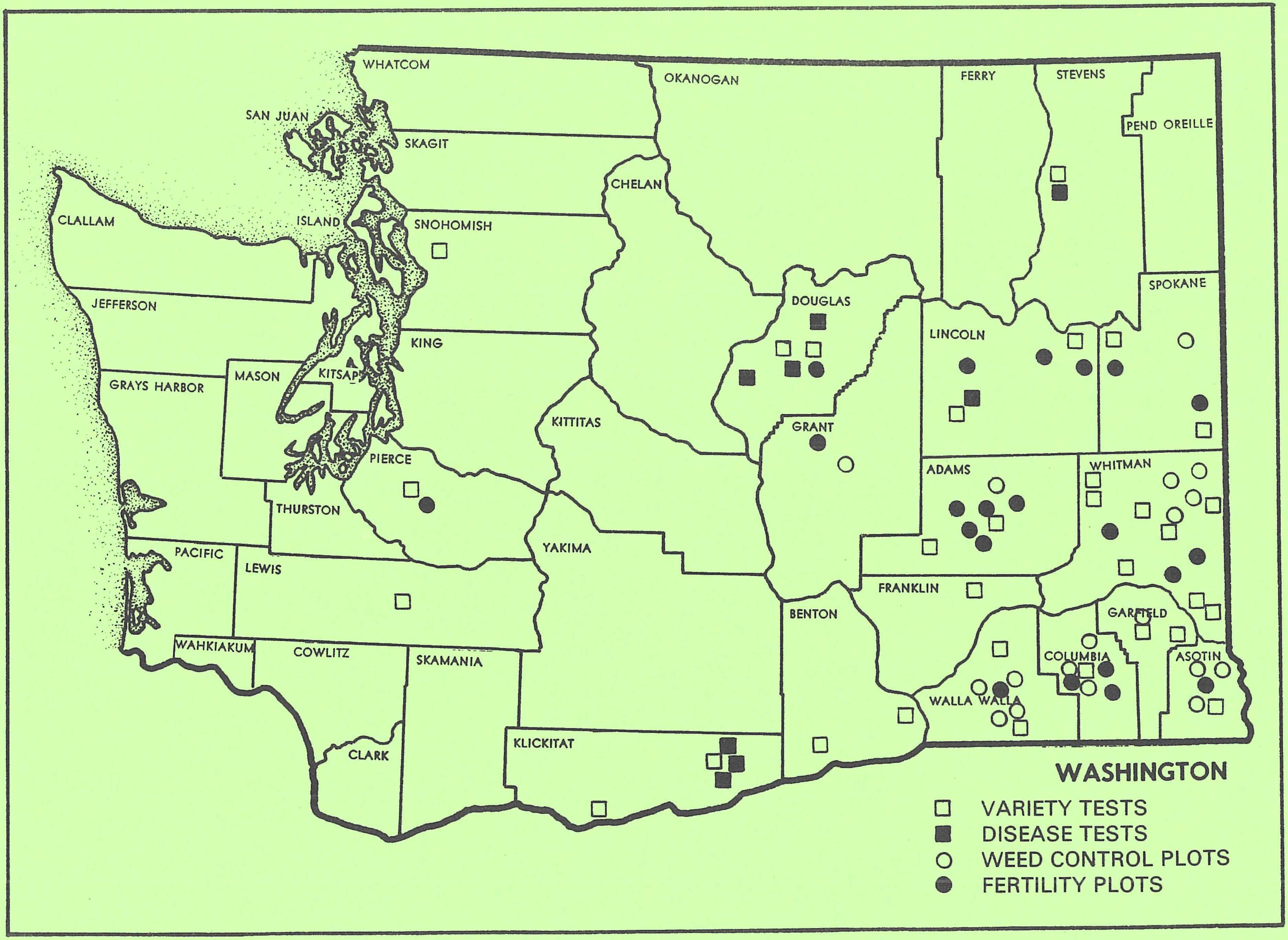
WSU FIELD DAYS

June 23, 1977
Dry Land Research Unit, Lind

June 30, 1977
Palouse Conservation Station
Field Day, Pullman

July 7, 1977
Spillman Farm, Pullman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ADAMS
WHITMAN
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YAKIMA
PACIFIC
LEWIS
FRANKLIN
BENTON
GARFIELD
WAHKIAKUM
COWLITZ
SKAMANIA
COLUMBIA
ASOTIN
WALLA WALLA
KLICKITAT
CLARK
WASHINGTON
VARIETY TESTS
DISEASE TESTS
WEED CONTROL PLOTS
FERTILITY PLOTS

WELCOME TO THE FIELD DAY

The Field Day Brochure includes research at the Dry Land Research Unit, Lind, Palouse Conservation Research Station and Spillman Agronomy Farm, Washington State University. Combining the information into one brochure gives you an opportunity to learn about the results of the wheat, barley, oat, pea, lentil, herbicide, fertility and management research programs being conducted in all areas of eastern Washington. It is hoped you will find information that will help you in your farming program.

The plant breeding work and the studies on diseases, weed control, wheat milling and baking quality, and barley malting quality are cooperative projects of Washington State University--College of Agriculture Research Center and the U. S. Department of Agriculture--Agricultural Research Service, and supported in part by funds from the Washington Wheat Commission, Washington Pea and Lentil Commission, Washington State Department of Agriculture, Washington State Crop Improvement Associations, Hail Insurance Adjustment and Research Association, and the Pacific Northwest Crop Improvement Association. In addition many commercial companies supply cash grants and materials for specific research programs.

The University farms do not meet all the research needs for disease resistance and the effect of the environment on different plant types. Farmer cooperators provide land at no cost to research workers for the testing program. Without the cooperation of these farmers the research program would be curtailed. The cooperators are listed on the contributors' page in support of research.

This brochure is intended to provide you with a brief progress report and to present some of the highlights of the programs you will visit. The articles will be supplemented by discussions and exhibits at the various stops to be made on the Field Day Tours.

Reports from the research conducted by Washington State University, as well as from neighboring states, is part of the educational program of the Cooperative Extension Service. Publications covering many topics that will aid you are available in the county agent's office. You can obtain a copy of these publications by visiting your local county agent's office.

Edwin Donaldson, Chairman, Dry Land Research Field Day, Lind
Kenneth J. Morrison, Chairman, Spillman Farm Field Day, Pullman
Carl F. Engle, Chairman, Palouse Conservation Research Station Field Day

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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 was 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 residence and machine storage built shortly after the station was established. The old barn was dismantled in April 1973. A small elevator was constructed in 1937 for grain storage. A modern office and attached greenhouse were built in 1949 after the old office quarters were burned. In 1960 a 40' x 80' metal shop was constructed with WSU general building funds. In 1964 an addition to the greenhouse was built with a Washington Wheat Commission grant of $12,000 to facilitate breeding for stripe rust resistance. In 1966 a new deep well was drilled testing over 430 gallons per minute. A pump and irrigation system were installed in 1967. With the addition of a 12' x 60' trailer house residence, improvements in 1966 and 1967 amounted to over $35,000 with more than $11,000 of this from Wheat Commission funds and the remainder from state funds. 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 60th field day. Visitors are welcome at any time. Their suggestions are appreciated.

HISTORY OF SPILLMAN FARM

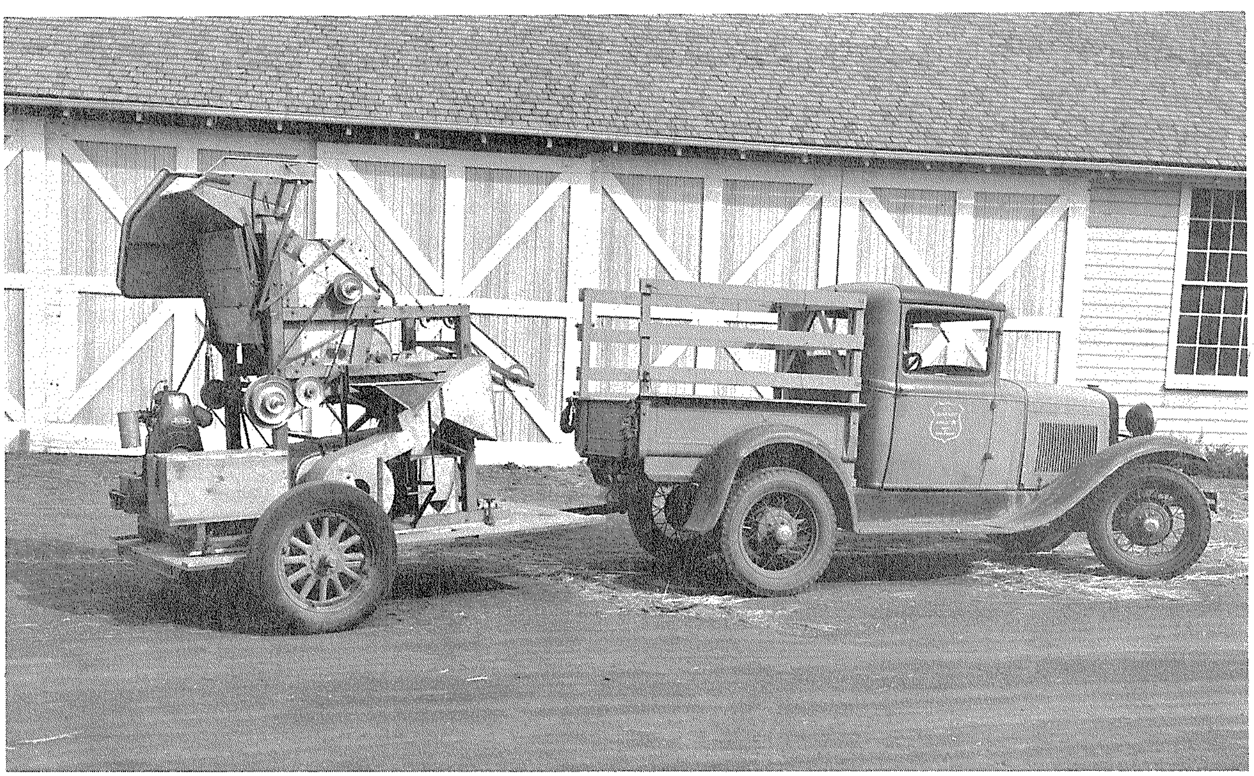
In the fall of 1955, 222 acres of land were acquired from Mr. and Mrs. Bill Mennet at the arbitrated price of $420 per acre. The money for the original purchase came as the result of a fund drive which raised $85,000 from industry and wheat growers. In addition $35,000 came from the Washington State 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.



Vogel nursery thresher built 1934.

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.	1976	1977	56 yrs. av. (in)
January	34	22	.93	.21	1.05
February	42	24	.86	.22	.88
March	53	32	.59	.75	.73
April	63	35	.65	.08	.64
May	72	42	.43		.75
June	83	45	.57		.89
July	90	52	.29		.24
August	90	50	.74		.32
September	79	45	T		.53
October	65	38	.23		.88
November	47	29	.14		1.21
December	37	26	.30		1.27
			5.73		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.

HARD RED WINTER WHEAT BREEDING AND TESTING

E. Donaldson and M. Nagamitsu

Hard Red Winter Wheat improvement in Washington is conducted at the Dry Land Research Unit at Lind. Primary emphasis has been placed on increasing yields 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, winter hardiness 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.

Recently selections having up to 4% higher protein than Wanser have been identified among progeny of crosses with Nebraska selections. Unfortunately, the selections identified to date do not have adequate bread baking properties to be considered for release. A few selections with 2% higher protein than Wanser may prove satisfactory after more testing.

Some agronomic characteristics of recommended varieties and the older varieties they replace are given for six locations in eastern Washington in tables; 2, Lind; 3, Horse Heaven Hills; 4, Connell; 5, Finley; 6, Waterville, and 7, Harrington. These data are from rod row nurseries. Table 8 gives the data from large scale field plots at Lind. 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 2. Summary of agronomic characteristics of winter wheat varieties grown at Lind in rod row nurseries. 1952-76.

Variety	Av. plant ht.	Av. test wt.	1976 yield bu/a	Av. yield bu/a	Yield % Kharkof	No. years grown
Nugaines	26	61.9	30.0	39.4	127	12
Luke	24	60.7	30.8	35.6	125	8
Sprague	26	61.2	30.8	34.7	124	6
Daws	30	59.9	23.0	39.9	127	3
Moro	30	59.1	33.1	37.6	119	13
Paha	27	60.4	31.3	39.4	131	10
Barbee	26	59.0	*	37.6	133	5
Wanser	31	62.0	25.6	35.8	113	13
McCall	31	62.3	30.2	38.2	118	12
Kharkof	33	60.6	26.1	30.4	100	22

*Not grown in 1976

Table 3. Summary of agronomic characteristics of winter wheat varieties grown in the Horse Heaven Hills in rod row nurseries, 1951-76.

Variety	Av. Test wt.	1976 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. Years Grown
Nugaines	60.3	17.3	22.8	124	6
Luke	59.8	16.7	21.8	118	6
Sprague	60.6	21.9	22.6	120	4
Moro	57.6	21.0	20.4	120	8
Paha	59.2	14.3	21.6	117	6
Wanser	60.8	20.7	20.7	120	9
McCall	60.9	19.9	20.3	117	9
Kharkof	60.7	16.9	18.4	100	16

Table 4. Summary of agronomic characteristics of winter wheat varieties grown at Connell in rod row nurseries. 1975-76.

Variety	Av. Test wt.	1976 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. years grown
Nugaines	62.3	38.1	43.1	110	2
Luke	61.6	43.2	43.7	112	2
Sprague	61.8	41.6	43.3	111	2
Moro	59.8	49.4	50.2	128	2
Paha	60.7	42.5	48.6	124	2
Wanser	62.5	40.1	42.2	108	2
McCall	63.0	39.9	42.2	108	2
Kharkof	60.8	39.3	39.1	100	2

Table 5. Summary of agronomic characteristics of winter wheat varieties grown at Finley in rod row nurseries. 1975-76.

Variety	Av. Test wt.	1976 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. years grown
Nugaines	63.7	37.9	41.0	114	2
Luke	62.3	40.2	44.8	124	2
Sprague	62.9	40.4	41.2	114	2
Moro	61.0	43.9	47.8	133	2
Paha	62.3	38.4	48.9	136	2
Wanser	64.0	36.1	36.6	102	2
McCall	64.1	33.1	36.0	100	2
Kharkof	62.5	35.2	36.0	100	2

Table 6. Summary of agronomic characteristics of winter wheat varieties grown near Waterville in rod row nurseries, 1952-76.

Variety	Av. Test wt.	1976 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. years grown
Nugaines	62.2	52.3	45.2	123	9
Luke	61.2	47.5	47.6	139	6
Sprague	60.7	48.8	42.2	132	4
Moro	59.4	49.2	44.4	120	9
Paha	60.9	51.5	46.8	134	7
Wanser	62.2	41.1	40.6	111	10
McCall	62.2	40.3	42.4	116	9
Kharkof	61.3	40.1	34.5	100	19

Table 7. Summary of agronomic characteristics of winter wheat varieties grown near Harrington in rod row nurseries, 1952-76.

Variety	Av. Test wt.	1976 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. years grown
Nugaines	61.9	40.1	41.3	137	11
Luke	60.8	41.8	42.0	142	8
Sprague	61.3	44.5	46.4	142	6
Daws	60.8	41.4	45.1	131	3
Raeder	60.0	*	44.0	121	2
Moro	59.4	42.5	39.7	132	11
Paha	60.6	37.5	42.6	146	9
Barbee	58.9	*	44.4	135	5
Wanser	62.3	40.7	39.2	132	10
McCall	62.8	40.9	42.1	142	10
Kharkof	61.3	31.0	34.7	100	23

*Not grown in 1976

Table 8. Summary of agronomic data for winter wheat varieties grown at the Dry Land Research Unit in drill strip plots, 1954-76.

Variety	Av. date head	Av. plant ht.	1976 yield bu/a	Av. yield bu/a	Yield % Kharkof	Av. test wt.	No. years grown
Nugaines	5/31	25	29.9	38.4	125	61.4	11
Luke	6/4	26	27.0	38.3	122	60.4	7
Sprague	5/31	28	31.0	38.0	133	60.6	5
Moro	5/31	31	31.8	39.1	127	58.6	11
Paha	6/4	28	35.0	42.3	135	60.1	7
Burt	5/30	30	29.4	35.7	115	60.9	21
Cheyenne	5/29	32	27.7	34.3	109	61.6	19
Wanser	5/29	31	28.0	36.5	116	61.7	13
McCall	5/30	31	28.4	37.6	121	61.9	12
Kharkof	6/7	34	24.6	31.0	100	60.5	21

SOFT WHITE WINTER WHEAT IMPROVEMENT
USDA Agricultural Research Service

Clarence Peterson, Robert Allan, Donald George, Allan Ciha, John Pritchett, David Henderson, Steven Hayward, Mary Robocker, Annette Patterson, Beverly Hunter, Debra Metteer, and Deborah Wilbert.

Washington produced 144.1 million bushels of wheat in 1976 on 3.2 million acres for a 45 bushel per acre average. This is above the ten-year average of 42.5 (1964-73) bushel per acre. Yields were reduced in some areas by plant diseases and a late spring frost. Stripe rust, *Cercosporella* foot rot, yellow dwarf and *Cephlosporium* stripe were the most important diseases. Leaf rust caused minor damage. Greenbugs and the oat-bird cherry aphids were severe during the fall in some areas. Harvest was delayed because of rain during August and some sprouting occurred.

Objectives:

The aim of the ARS breeding program is to breed semidwarf, high yielding, good quality, disease resistant white winter wheats for efficient and consistent production in the Pacific Northwest. Increased attention is being given to breeding wheats adapted to very early planting for effective control of soil erosion on summer-fallowed land. Attention will also be given to the development of winter wheats adapted for production under minimum and no-till management conditions.

New Varieties:

1. Daws, CI 17619, is a soft white common semidwarf winter wheat that is superior to Nugaines in winterhardiness. It is resistant to stripe rust and common bunt. The milling and flour qualities of Daws are similar to those of Nugaines. The grain yield of Daws is equal to or

slightly higher than that of Nugaines. It emerges slower than Nugaines. Daws is recommended for production in Idaho, Oregon, and Washington.

2. Stephens, CI 17469, (developed by Oregon State University), is a high yielding soft white common semidwarf winter wheat. It is resistant to stripe rust and common bunt and moderately resistant to *Cercosporella* foot rot. Stephens is susceptible to leaf rust, flag smut and dwarf bunt. It is less winterhardy than Nugaines. The grain yield of Stephens has been equal to or above Hyslop and Nugaines. The milling and flour qualities of Stephens are similar to those of Nugaines. It is recommended for production in Idaho, Oregon, and Washington.

3. Barbee, CI 17417, is a soft white club semidwarf winter wheat that has adult resistance to the stripe rust races presently found in the Pacific Northwest. Grain yield of Barbee is equal to or slightly better than Paha. Barbee emerges slower than Paha. The milling characteristics of Barbee are similar to those of Nugaines. Its flour qualities are similar to those of Paha. Barbee is recommended for production in Washington and Idaho.

4. Faro, CI 17590, (developed by Oregon State University), is a soft white club semidwarf winter wheat. It is resistant to stripe rust and common bunt. Faro is susceptible to flag smut, snow mold, leaf rust, and dwarf bunt. It has equalled or exceeded the grain yields of Paha. Faro is similar to Paha in emergence, winterhardiness, milling, and flour quality. It is recommended for production in Oregon and Washington.

New Promising Selections:

1. WA 6155, is a soft white club semidwarf winter wheat that has adult resistance to the stripe rust races presently occurring in the Pacific Northwest. Grain yield of WA 6155 is equal to or higher than that of Paha or Barbee. Its milling and flour qualities are similar to those of Paha. WA 6155 is on increase for possible release.

2. WA 6242, is a soft white common semidwarf winter wheat that has adult resistance to stripe rust races presently occurring in the Pacific Northwest. It is also resistant to common and dwarf bunt. Grain yield of WA 6242 is slightly higher than that of Nugaines and Daws. Its milling and flour qualities are similar to those of Nugaines.

New Entries in Western Regional Soft White Winter Wheat Nursery (1976-77):

1. WA 6361, (VH 73428) is a high yielding soft white common winter wheat. It is resistant to common bunt, stripe rust, and dwarf bunt.

2. WA 6362, (VH 74629), is a high yielding soft white common winter wheat. It is resistant to stripe rust, common bunt, flag smut and dwarf bunt.

3. WA 6363, (VH 74801), is a high yielding soft white common winter wheat. It is resistant to common bunt, leaf rust and stripe rust.

Disease Resistance:

1. *Cercosporella foot rot yield nursery.* (1975-76). The nursery contained 132 varieties and lines and was seeded September 6, 1975. The entire nursery was inoculated with

Cercosporella foot rot organism in October. One-half of the nursery was sprayed with Benlate in March to control the *Cercosporella* foot rot. The mild winter followed by the cool, wet spring was ideal for the build-up of this disease. The Benlate sprayed portion of the nursery produced an average of 75 bushels of grain per acre. The inoculated unsprayed portion produced an average of 29 bushels per acre for a 61% reduction. The grain yield of Cerco, a line previously shown to be resistant was reduced 48%. Eleven of the new selections equalled or exceeded the grain yield of Cerco when inoculated with *Cercosporella* foot rot.

2. *Flag Smut.* Two nurseries of 720 lines each were seeded at Bickleton, Washington. The flag smut infection was poor at Naughts and moderate at Clarks. The following is the relative infection percent on our varieties:

   Nugaines, 3%; Hyslop, 18%; Stephens, 38%; Daws, 23%; Luke, 38%; Faro, 28%; Barbee, 5%; and Paha, 64%.

3. *Stripe Rust.* Stripe rust was quite severe in the nurseries at Pullman. Data were also collected at Walla Walla and Central Ferry. Stripe rust reduced the yields of Paha and Nugaines in Washington in 1976. The adult resistance of Nugaines was not effective because of the long, cool, wet spring.

4. *Dwarf Bunt.* About 11,000 selections (F_3 and advanced lines) were seeded at Rice, Washington and inoculated with dwarf bunt. The infection was very erratic. Disease data were recorded and this information was used in the selection of lines for planting in 1976-77. Fifty-nine lines were sent to Dr. James Hoffmann, at Logan, Utah for extensive screening Seven lines (Table 9) have dwarf bunt resistance that is equal to or better than the resistance of Luke.

Table 9. 1976 Data on Bunt Resistance
(Dr. James Hoffmann)

		% Infection			
	Resistance	Common		Dwarf	
Selection	Factor	Ave.	Highest	Ave.	Highest
Nugaines	1+4	35[1]	95	45[2]	70
Luke	9+19+?	1.7	10	8.3	20
WA6155	1+4	28.0	58	43.0	75
WA6242	9+10+?	0.2	1	4.5	12
VH75333	9+10+?	2.2	5	10.0	28
VH74482	9+10+?	0.2	1	4.0	12
WA6362	9+10+?	0.2	1	3.0	7
VH75297	9+10+?	0.7	2	4.5	9
VH75314	9+10+?	0.0	0	4.0	7
VH74554	9+10+?	1.0	3	10.0	25

[1] Average infection of 6 races.

[2] Average infection of four locations.

Adaptation:

It is difficult to measure adaptation and various methods have been proposed. We have decided to use the standard deviation of the variety over a number of locations when adjusted to the mean of the nursery. The standard deviation is determined by subtracting the yield of the variety from the mean of the nursery for each location and treatment and then obtaining the standard deviation on these values. *A high standard deviation would show that the variety performed in an erratic manner. A variety with a low standard deviation would be stable across locations and treatments.*

The data (see table 10) shows that the early semidwarfs (Nugaines, Hyslop, McDermid, and Luke) were quite erratic and the new ones (Daws, WA 6241, etc.) were stable. Also the clubs appear to be more stable than the early semidwarf commons.

Table 10. Average Yield and Standard Deviation of Winter Wheats Grown at Pullman (Late), Pomeroy, Walla Walla and Harrington (two fertility rates) for Three Years

	1973-74		1974-75		1975-76	
	Bu/A	Stand. Dev.	Bu/A	Stand. Dev.	Bu/A	Stand. Dev.
Kharkof	42.5	11.0	45.5	9.0	40.3	10.4
Nugaines	55.0	3.6	63.2	14.3	62.1	13.1
Hyslop	60.1	13.0	64.8	16.7	76.5	11.2
McDermid	58.2	10.5	62.2	14.3	66.6	6.4
Luke	59.6	8.9	65.6	14.5	69.8	4.9
Sprague	47.1	6.4	57.5	10.2		
Cerco	56.7	8.7	61.6	7.8	72.1	6.6
Stephens	60.7	6.4	61.0	10.8		
Daws	58.1	4.8	59.2	3.8	76.9	5.0
WA 6241	58.7	3.5	74.0	8.9	76.5	3.3
WA 6242			70.7	4.1	74.8	3.4
WA 6361	60.1	5.5	61.5	6.6	80.4	10.0
WA 6362			70.5	8.2	80.6	8.0
VH 71414	55.5	6.1	62.0	6.7	74.5	5.9
Moro	40.3	13.3	45.3	2.7	56.6	9.5
Paha	48.8	7.7	58.1	8.3		
OR 7146	45.8	6.5	54.7	5.9	71.8	5.0
Faro	50.7	5.3	59.1	6.9		
Barbee	54.8	5.9	60.3	7.4	75.8	5.4
WA 6155			64.2	16.5	75.8	2.0

Triticale:

The highest yielding triticales in the spring and winter yield nurseries at Pullman, Washington (1975-76) were 6TA476, VT72229, MT36 and Beagle. The spring types came through the winter in excellent condition and some of them produced more grain than the winter wheat checks. In the spring seeding, one triticale, MT36, exceeded the grain yield of the spring wheat check, Twin, and 6TA476 equalled the yield of Twin. Test weights of the triticales are still quite low when compared with the wheat checks. The winter triticale WTM07326 equalled the yield of Luke, indicating that progress is being made in the development of better winter types. The actual winterhardiness of WTM07326 has not been determined.

WINTERHARDINESS

Donald W. George and Beverly Hunter

Drought has the virtue of increasing winterhardiness. The fall of 1976 was dry with mild days and frosty nights well into December–ideal weather for hardening off healthy young wheat plants. Consequently, all varieties were capable of surviving colder than normal temperatures and very little winterkill was observed. The spring variety, Marfed, survived with no loss of stand in both the Central Ferry Winterhardiness Nurseries and at Pullman. The Marfed border row in the Yield Nursery on the Kramer farm survived only 10-20%. Survial among the winter wheats appeared satisfactory in all varieties.

Because of the extreme hardening of the winterhardiness nursery-grown material, it was found that the freezer would not operate cold enough to produce good differential kill in the crown freezing tests. Consequently, very little information was obtained from the crown freezing tests performed.

Two winterhardiness nurseries were grown at Central Ferry. In the past three years, the Central Ferry Nursery has been heavily infested with green bugs soon after emergence and severee Barley Yellow Dwarf infection has resulted. This was the case again this year in the earlier-seeded nursery. The second planting, made only two weeks later was almost free of BYD and this may prove the only practical way to produce plants in which winterhardiness results are not influenced by the virus infection. Unfortunately, the later seeding will not be representative of early-seeded wheat as we would prefer.

The early-seeded nursery will probably be maintained for the plant development data it provides and for the excellent BYD infection.

These Central Ferry Nurseries are proving attractive to Canada geese residents along the Snake River and means of discouraging them from grazing the plots must be found. Propane-firing cannons, designed for bird scaring have proved helpful so far, but wildlife experts predict that eventually the geese will become accustomed to the noise.

STAND ESTABLISHMENT AND RELATED PROBLEMS

Donald W. George and Beverly Hunter

Environmental conditions in 1976 produced an intermediate level of postharvest dormancy. This was unexpected, since the spring was cool. Cool weather during a critical 5-day period of the soft dough stage of grain development is known to result in low dormancy, while hot weather at that time produces maximum postharvest dormancy. A series of a few hot days around July 1 may have been the deciding factor.

This may illustrate very well the unreliability of postharvest dormancy as protection against head sprouting. At best, it is not very effective under our conditions, and the protection it does offer is dependent upon having warm-to-hot weather during a time period when cool weather is more likely to occur. Given our range of maturity dates, as influenced by choice of variety and planting date, and the varying latitudes and altitudes where wheat is grown, it is extremely unlikely that any variety can consistently produce high postharvest dormancy on an area-wide basis.

On the other hand, morphological characteristics such as head attitude, awns, and glume texture, and possibly germination inhibitors, may provide a significant degree of protection from head sprouting.

However, it is very likely that head sprouting caused by local rainy periods will continue to occur when weather conditions favor it. Since sprout damaged wheat has limited usefulness in commercial channels, any that is produced should be identified and held separate when marketed. While sprout-damaged wheat is unacceptable for some purposes, the high alpha-amylase activity resulting from head sprouting does not necessarily reduce the value of wheat for all uses. Furthermore, the base level of alpha-amylase in sound grain differs with variety and therefore should be susceptible to modification through breeding. This quality factor has received little attention in the past.

Since an increase in alpha-amylase is known to take place very early in the germination process, it may develop that varieties inherently high in alpha-amylase are the ones which germinate and emerge most rapidly. This is still speculative and unproven, but reasonable. If confirmed by investigation, it will mean that rapid emergence and low alpha-amylase content tend to be mutually exclusive.

As a general rule, red seeded wheats tend to be fairly dormant, white seeded ones less so. Among our commercial varieties grown at any one location; Moro, followed by Sprague and Luke, is nearly always least dormant while Nugaines, Hyslop, and always Wanser, will be among the most dormant. See Table 11.

Table 11. Typical Postharvest Dormancy of Wheat Varieties Six Weeks after Harvest. Seed Germinated Four Days at 86°F with Ample Moisture.

Variety	PI*	Variety	PI*
Moro	140	Gaines	50
Rew	135	Hyslop	50
Sprague	125	Yamhill	50
Luke	115	Peck	45
Barbee	90	Raeder	45
Daws	90	Nugaines	40
Paha	80	Wanser	15
Coulee	75	Brevor	10
Stephens	70	McCall	10
Faro	no data	Cheyenne	5
McDermid	60	Old Seed (any variety)	190-200

*PI = Promptness Index. If all seeds germinate on the first day of test, PI = 200. Any seeds remaining ungerminated after four days count as 0.

STAND ESTABLISHMENT AND GENETIC BACKGROUND

R. E. Allan, J. A. Pritchett, M. A. Patterson, M. L. Robocker

Stand establishment problems among semidwarf wheat are more serious in some genetic backgrounds than others. Two years of tests show that with respect to emergence rate, the two-gene semidwarf condition is best tolerated in Golden, Omar, and Marfed genetic backgrounds, respectively. Brevor, Burt and Nord genetic backgrounds were the least tolerant of the two-gene semidwarf trait. Golden, Omar and Burt, however, are more tolerant of the one-gene semidwarf trait than are the backgrounds of Brevor, Itana and Marfed. Some backgrounds were more consistent in their performance for certain stand establishment criteria (emergence rate index, total stand) over the two year period. For two-gene semidwarfs, Golden and Marfed backgrounds showed little variation in their relative performance between the two years whereas marked differences occurred for the Itana and Omar backgrounds. Golden and Omar backgrounds exhibited consistent emergence performance as one-gene semidwarfs whereas erratic behavior was typical of the Itana and Marfed backgrounds for this semidwarf level. Chances for improving the overall stand establishment capabilities of Pacific Northwest wheat could be enhanced by using genetic backgrounds that give stable, optimum emergence and by avoiding those backgrounds that give mediocre, inconsistent emergence.

WHEAT ISOLINES REVEAL SPECIFIC ADAPTATIVE TRAITS FOR DIFFERENT MANAGEMENT SYSTEMS

R. E. Allan, R. E. Witters, J. A. Pritchett,
M. A. Patterson, M. L. Robocker

The genetic curiosity called "double dwarf" in wheat may find some practical value in specific management situations in Washington and other areas of the Pacific Northwest. Under shallow soil/summer fallow conditions (near Bickleton, WA), isolines of seven different genetic backgrounds consistently showed that the short, two-gene semidwarfs were the best yielders under this management system. These short dwarf types produced 8 to 74% more grain than their respective tall sister lines and averaged 46% higher in yield overall of the genetic backgrounds. The more commonly used one-gene semidwarf types (the dwarfing system employed in Nugaines, Hyslop, Luke, Paha and Spague) only averaged 24% more grain than their tall sibs (range of 4 to 49% more). The two-gene types rarely yielded well at any of the other sites or for other management situations. Why do double dwarfs consistently yield well under shallow soil conditions? We think it is because they produce a high proportion of grain in relation to straw. That means they don't waste water and other plant nutrients to grow excess straw. Also, Dr. Witters has shown this short plant type is particularly efficient in extracting water from the upper portion of the soil profile.

Other significant findings learned from this adaptation--plant height study are: 1) the one-gene semidwarf types were more generally adapted to the array of management systems sampled than either the two-gene semidwarf or standard height phenotypes; 2) semidwarf growth habit contributed little or no yield advantage under recrop management except when incorporated into low yield potential, weak strawed genetic backgrounds such as Omar and Golden; 3) no one line gave maximum yield potential at all sites, however. Rather, five distinctly unsimilar genetic types with different combinations of plant heights, awn types and genetic backgrounds represented the top yielding lines at the six test sites.

This finding emphasizes the need to breed diverse genetic types for the equally diverse environment and management systems occurring in the region. No one genotype is universally adapted to all of these situations. This explains why it is necessary to have several varieties from which growers can choose and why it is unrealistic to think only one or two varieties would suffice for wheat production in our state.

COMPARISONS OF FALLING NUMBER VALUES OF WHEAT ISOLINES

R. E. Allan, G. L. Rubenthaler, J. A. Pritchett,
M. A. Patterson, M. L. Robocker

Pacific Northwest wheat again suffered some damage from harvest rains in 1976. Comparative tests with eleven isogenic line populations subjected to preharvest rain showed that the degree of alpha-amylase activity as measured by the falling number (F.N.) test relates to plant height, awn expression and spike type. The two-gene semidwarf phenotype had lower F.N. values (higher alpha-amylase activity) than their one-gene semidwarf phenotypes in all genetic backgrounds but two. Excluding the Golden background, alpha-amylase activity of two-gene semidwarf lines were .1 to 1.0 times greater than their one-gene sibs. Apparently the microenvironment of two-gene types is more conducive to increased enzyme activity.

The one-gene semidwarf phenotype had significantly higher F.N. values (lower alpha-amylase activity) than their taller standard height sibs among seven genetic backgrounds yet the values were similar in four others. Low F.N. values of standard height phenotypes related directly to increased lodging.

F.N. values of awnless sibs were 26 to 54 units higher than their awned counterparts and the differences were significant for seven of nine comparisons. The average F.N. values for awned vs. awnless types in the Burt, Brevor and Omar backgrounds were 260 vs. 314, 298 vs. 324, and 139 vs. 166, respectively. Awnless types may shed rain and dry out faster than awned types.

An interaction occurred for F.N. values between spike type and genetic background. Lax Omar lines had higher F.N. values when compared to club Omar lines (184 vs. 239), yet in the Burt background the reverse was true (174 vs. 239). This reversal may be caused by differences in orientation of lax Omar and Burt spikes. Lax Omar spikes nod whereas lax Burt spikes remain erect, as do club spikes of both backgrounds. Nodding spikes conceivably could shed rain more effectively than erect spikes.

SOME DISORDERS OF WINTER WHEAT

G. W. Bruehl and Otis Maloy

The drought this season has revealed some problems that have led to confusion and some misidentifications. For this reason we wish to describe a few abnormalities.

Wire worm damage. Entomologists tell us that wire worms work in moist soil. This year, when the worms were active, the worms were deeper in the soil. Instead of the usual attack at the base of the shoot, most damage that we have seen has been to roots themselves, below the base of the shoot. If you have plants that developed well and then died while adjacent plants lived; dig the plants and inspect the roots. Chances are you will find that the main roots of the dead plants have been chewed off neatly as if cut by a knife.

Sulfur deficiency. Wheat that is bright, relatively uniform yellow, with the yellow plants in solid patches rather than as scattered individuals, is probably the result of sulfur deficiency. Cool weather followed by dry conditions has aggravated low sulfur conditions because the soil bacteria have been unable to make sulfur available for plant use.

Yellow dwarf. Yellow dwarf has been observed in early-seeded, vigorous winter wheat that had adequate water, along the western half of the drive between Washtucna and Othello along highway 26. It is most obvious when looking at flag leaves toward the sun. Yellow dwarf symptoms are very different from those of sulfur deficiency. The sulfur-deficient plants were relatively uniformly yellow, especially the younger leaves. With yellow dwarf, there will be both green areas and portions of the leaves, usually near the tips, that are bright yellow, red, or purple, particularly on flag leaves. Because yellow dwarf virus is spread by aphids, yellow dwarf can occur in individual plants or in patches, depending upon the distribution of infective aphids earlier in the season.

Powdery mildew. Powdery mildew is a commonly observed problem in winter wheat. It appears as gray-white downy patches or tufts on the lower leaves and leaf sheaths. There often is an island of green tissue under the white fungus growth on an otherwise yellow leaf.

There is no evidence that powdery mildew is causing measurable losses in winter wheat and for this reason control measures have not been considered to be feasible.

Non-parasitic leaf spots. On some varieties such as McDermid and Hyslop and possibly on Gaines and Nugaines as well, brown spots often develop on the leaves early in the spring. There does not appear to be any organism associated with the spots nor do they seem to affect the plant. The spots are uniform brown in color, variable in size and scattered rather regularly over the leaves. However, there are several fungus leaf spots of wheat that resemble this non-parasitic condition.

SNOW MOLD AND SNOW ROT ARE DIFFERENT

Pat Lipps and G. W. Bruehl

In the 1975-1976 season, Sprague as well as other winter wheats died in areas receiving drainage water in the Indian Reservation portion of Okanogan County. Field observations revealed that a good snow cover which melted slowly provided running or standing water beneath the snow. The snow rot developed only in association with water or ice.

The tops of plants were rotted and the entire shoot section of the crown was destroyed. Thus recovery was impossible because growing points were killed. The roots of these plants were not damaged.

Laboratory and greenhouse trials have proven that a *Pythium* sp. described in Japan and one described in Canada killed these plants. It is suspected that another, as of yet unidentified, species was important also.

Pythium snow rot does not occur on well-drained sites. Excess water prevents the snow mold fungi from developing whereas the *Pythium* species are unaffected by saturated conditions.

When conditions favor snow mold, the snow rot disease does not develop. When conditions favor *Pythium,* the snow molds don't develop. If dead wheat is found in drainage ways or low spots after prolonged snow cover, *Pythium* snow rot was probably responsible.

We suspect that wheats resistant to snow mold will not protect against snow rot and that losses from it will be unavoidable.

GENETIC STUDIES ON TOLERANCE OF WHEAT TO *CERCOSPORELLA* FOOT ROT

R. E. Allan, C. J. Peterson, G. W. Bruehl,
J. A. Pritchett, M. A. Patterson, M. L. Robocker

It is now apparent that we can achieve a high level of tolerance to *Cercosporella* foot rot. We've tested germ plasm from France that has outstanding resistance which is derived from a close relative (*Aegilops ventricosa*) of the bothersome weed, Goatgrass.

Last year in a test where foot rot was particularly severe, we were able to make an accurate comparison of the effectiveness of the tolerance levels possessed by an array of wheat germ plasm, The data below (Table 12) shows the yields and test weights of several varieties and the French selections under foot rot inoculated and non-inoculated conditions.

Table 12

Variety	Test Weight (lb/bu) Foot Rot	Benlate	% Reduction	Yield (gm/32 sq. ft.) Foot Rot	Benlate	% Reduction
Hyslop	53.2	58.7	9	772	1642	53
Nugaines	52.8	61.2	14	403	1760	77
Paha	55.7	58.8	5	896	1449	38
Luke	55.2	58.5	6	1341	1859	28
Nord	59.3	60.2	1	1441	1991	28
Cerco	55.7	59.2	6	1183	2187	46
VPM/Moisson, 1	58.7	58.3	0	1724	1784	3
VPM/Moisson, 2	59.2	58.3	0	1818	1818	0

Clearly, none of our existing varieties approach the high level of tolerance to *Cercosporella* foot rot that is possessed by the French VPM/Moisson selections. These selections also appear to have yield potential even in the absence of foot rot damage, which suggests that we may be able to transfer their tolerance to high yielding, locally adapted wheats. We have over 100 F_1 hybrids derived from crosses of these two French lines to adapted varieties and selections. They are growing in the field this year. We plan to use some of these crosses to study the inheritance of tolerance to *Cercosporella* foot rot—whereas progeny of other crosses will be used to select types adapted to Washington conditions that have resistance comparable to the French lines.

In a genetic study which is already underway, we are attempting to determine whether the genes for foot rot tolerance carried by the varieties Viking, Druchamp, N98, Cerco, and Cappelle Desprez, are the same or different. All of these varieties are of Northern European origin or have parentage from that region. We are particularly interested in learning which varieties possess different types of resistance since it would then be possible to breed wheat selections that combine both types of resistance. Such resistance would be even more effective in breeding to control this serious disease.

CONTROL OF CERCOSPORELLA FOOT ROT BY BENLATE, 1975-1976 SEASON

R. Machtmes and G. W. Bruehl

Benlate was applied by ground in 20 gallons of water per acre in March to early-seeded Nugaines winter wheat near Waitsburg (Walla Walla County) and near Hay (Whitman County). Foot rot lesions were abundant at the time the fungicide was applied. At harvest the sprayed wheat had a good color, had a few white heads, and had not lodged. Much of the unsprayed wheat was filled with heads and some of it had lodged.

Harvests were taken by the cooperating farmers using their own combines. The yields obtained are presented in Table 13. The yields of the 1975-76 season indicated that the one pound rate is better than the 1/2 pound rate where potential yields are high.

Table 13. Effect of Benlate on yields of Nugaines with Cercosporella foot rot, 1975-1976.

Rate of Benlate	Waitsburg		Hay	
	Sprayed	Control	Sprayed	Control
1/2 lb	94	85	54	41
1 lb	108	85	66	46
2 lb	89	66	70	47

MULTILINE VARIETIES TO COUNTER STRIPE RUST

R. E. Allan, R. F. Line, J. A. Pritchett,
M. A. Patterson, M. L. Robocker

Several new races of stripe rust has become prevalent in the state in the last few years. These races can attack Paha, Norco, Yamhill, Moro, Crest, Fielder, and Fieldwin. Multiline varieties may be a feasible way to reduce the vulnerability of the state's wheat crop to stripe rust and buffer the potential damage that new races could cause. Resistance of multilines is not based on a single type. Rather it represents a mixture of several genetically different forms, so a new virulent stripe rust race can attack only a small proportion of the plants that make up the multiline.

Last year a winter semidwarf club multiline of 10 components yielded 66 bu/ac vs. 64 bu/ac for the combined yield of the 10 components when averaged over seven test sites in eastern Washington. The multiline exceeded the yield of Paha by 1 to 22 bu/ac (average increase: 10 bu/ac) in 1976. This multiline has exceeded the yield of its individual components in 82 of 114 comparisons at 4 to 7 test sites during the last 2 years. The performance of the multiline compared to its components was poorer in 1976 than in 1975. We think this was due to the increase of stripe rust races capable of attacking 3 of the 10 components more severely than in previous years. Four multilines have been sown at six test sites for the 1977 crop. These include two different semidwarf club types, one semidwarf and one standard height hard white winter type. Little or no stripe rust is present at the test sites this year, however. Nevertheless, this should give us an excellent opportunity to measure the agronomic potential of multiline varieties compared to conventional varieties in absence of the disease.

RUST, POWDERY MILDEW, AND SMUT

Roland F. Line

RUST

Three rusts (stripe rust, leaf rust, and stem rust) occur on wheat in the Pacific Northwest. Stripe rust appears as golden-yellow, long, narrow stripes on the leaf surface and glumes; leaf rust appears as small, red pastules on the leaf surface and leaf sheath; and stem rust appears as larger, red-brown, diamond-shaped pastules on the leaf surface and stems. Stripe rust and leaf rust over winter on wheat and increase during the spring. Stripe rust develops during the cool temperature of early spring. Leaf rust develops slightly later. Stem rust usually appears late in the season and seldom causes damage. Therefore, most research in Washington is on control of stripe rust and leaf rust. The major emphasis is on: (1) monitoring the diseases to determine where they are, what wheats are vulnerable, and the potential importance of new races; (2) identifying and utilizing various types of resistance; (3) evaluating fungicides at various rates and schedules for control of rusts; (4) studying the factors that contribute to rust epidemics; and (5) determining the amount of damage caused by the rusts so that priorities can be determined. The research is conducted at several field sites throughout the region and under controlled conditions in the greenhouse.

The monitoring program involves: (1) planting trap plots, consisting of varieties that differentiate races and varieties with various types of resistance, at sites throughout the region, and (2) collecting rust specimens and testing them on selected wheats under controlled conditions. Races of rust are identified by their ability to attack certain varieties. New races can arise by mutation and thus, are able to attack varieties that were previously resistant. In 1974, two new races appeared on wheat in the Pacific Northwest–one on Yamhill in the Skagit Valley, and one on Paha near Walla Walla. In 1975 and 1976, each of the races severly damaged the varieties on which they occurred causing losses as great as 50%. In 1975, a third race appeared on Norco. Consequently, Norco was not released to be grown in the area. In 1976, the Norco race plus at least one new race were found to also attack the spring wheat, Fielder. Stripe rust was unusually severe in 1976. Because of dry conditions it should not be as destructive in 1977. At least two races of leaf rust occur in the area. The newest race attacks Norco and Hyslop which have been resistant in the past. Most existing varieties are susceptible to leaf rust. However, we have new lines coming along with better resistance.

Research on resistance to stripe rust and leaf rust is being conducted at several field sites where the rusts occur and under controlled environmental conditions. Several types of resistance to stripe rust have been identified. Some types of resistance are only effective against certain races, such as the resistance of Paha, Moro, and Yamhill. Other types are effective against all races but are affected by temperature and stage of growth. Gaines, Nugaines, Wanser, McCall, Hyslop, McDermid, and Luke all have various degrees of the latter type of resistance, which is referred to as nonspecific resistance. They are completely susceptible in the seedling stage and at later stages when the temperature is low, but are relatively resistant in later stages at high temperatures. The various types of resistance are being incorporated into new varieties. A similar project on evaluation of wheats for resistance to leaf rust has been initiated and several types of resistance have already been identified.

As part of the research program we are evaluating fungicides at various rates and schedules at several locations. Some systemic fungicides have provided good control of both rusts. They are even more effective when the varieties have some resistance. Integration of resistance and chemical control with changes in management practices to reduce inoculum or rate of disease development appears to have great promise in controlling the rusts.

POWDERY MILDEW

Powdery mildew is prevalent throughout the region, especially in areas with higher rainfall and in irrigated fields. Accurate measurement of the damage caused by mildew is difficult. The amount of damage caused by mildew depends upon the amount of mildew and the environment. In general, mildew is not as destructive as the rusts. Mildew frequently occurs in the same fields with rusts, consequently, studies on resistance to mildew and chemical control are often made in conjunction with studies on control of the rusts. Most varieties grown in the region are susceptible to mildew, however, there are good sources of resistance, which are being used in the breeding program.

SMUT

Flag smut is found in most counties of Washington and a few counties of Oregon and is most severe in Klickitat County, Washington. It is only important in the Pacific Northwest. Varieties and lines have various degrees of resistance. Wanser is very resistant; Nugaines, Gaines, and Moro have relatively high degrees of resistance; Luke and Hyslop are moderately susceptible and Paha and Faro are very susceptible. A few new, systemic chemicals will control flag smut. Of those that are effective, only Vivavx has been cleared by the Environmental Protection Agency for use as a seed treatment. It will control both seedborne and soilborne flag smut. Planting early and planting 2-3 inches deep increases flag smut severity. Higher soil temperatures increase the disease. The effects of cropping sequence, tillage practices, and other management practices in relationship to flag smut survival and severity and the relationship of flag smut to yield and quality of wheat are being studied. The most effective control program for flag smut appears to be a combination of several methods.

Dwarf bunt (TCK) has become more important in recent years because of restriction on the sale of contaminated grains in certain countries. At present, cooperative studies, involving Dr. Duran and Dr. Schafer in Plant Pathology, and several plant breeders, are in progress to obtain information on the factors that contribute to dwarf bunt, the mechanisms of dwarf bunt resistance, and to identify new resistant wheats.

Common bunt is under control at present because of seed treatments and resistant varieties. However, if the present treatments were not available it could again become a problem. In cooperation with Dr. Hoffmann at Logan, Utah, Jack Waldher is evaluating new sources of resistance, new breeding lines, and new seed treatments for control of common bunt as well as control of dwarf bunt.

RESEARCH ON WATER STRESS AND DRYLAND FOOT ROT OF WHEAT

R. J. Cook and R. I. Papendick

Studies are in progress in plots at Harrington (Kramer Ranch) and also on the Lind station to compare wheats for ability to withstand water stress and resist the dryland foot rot caused by *Fusarium*. The Harrington site has a low level of infestation by the *Fusarium*. The Lind site was infested on purpose and presently has about 30,000 spores per cubic inch of soil to a depth of 4 inches.. Twelve standard, commercial wheats are under detailed study at Harrington for water use and water stress characteristics. At Lind, 1,730 hard red wheats from the USDA world collection and representing wheats from Russia, Mainland China, Saudi Arabia and many other countries, are under test. In addition, about 50 of the best advanced lines of hard red winter wheats from the Great Plains states and Pacific Northwest wheat breeding programs are under test at Lind. These wheats were seeded August 28, 1976, even before we knew 1977 would bring the worst drought on record.

Although it is still too early to be certain, observations at the time of this writing indicate major differences at Lind among the wheats in ability to withstand the water stress/dryland foot rot complex. Several wheats appear superior to Wanser. Nugaines was virtually dead at the time of this writing. The better wheats are being monitored closely, including by soil probe to measure water depletion rates from the 6-foot profile, and also by a special pressure instrument that measures water tension in the wheat plant. Every advantage is being made to identify the most drought resistant wheats.

Measurements are also being made on wheat in fields in the region to obtain scientific information on degrees of water stress in wheat in this year of unprecedented drought. Measurements of water stress in summer fallow wheat between April 25-27, 1977, in Adams, Lincoln, and Benton counties revealed wheat drawing water from the 4-5 foot layer with internal plant water tensions (suctions) of 400-500 lbs per square inch. Some wheat plants in the Horse Heaven Hills gave water stress readings of 600 lbs negative pressure per square inch, and were getting their water from the 5-6 foot layer. Normally, these levels of stress and depths of extraction are not reached until well after heading. This work is being expanded for the current year to obtain as much information as possible on the nature of water stress and the relationship of water stress to dryland foot rot.

EFFECT OF NO-TILL ON TAKE-ALL OF SPRING AND WINTER WHEAT

K. J. Moore and R. J. Cook

Take-all, caused by the soilborne fungus known as *Gaeumannomyces graminis,* can be a serious disease of recropped wheat grown under heavy irrigation in eastern Washington. The disease was particularly serious last year in certain hard red spring wheat fields under pivot irrigation. This disease is also important in the higher rainfall area of western Washington, and may occur in certain wet years in the annual cropped dryland areas of eastern Washington and adjacent Idaho.

At Lind, take-all of irrigated spring and winter wheat was increased under a no-till system of crop management, compared with the conventional methods of seed bed preparation. Take-all was also more prevalent in no-till winter wheat at Puyallup. The reason(s) for the increased incidence of take-all in no-till plots is (are) not known as yet. At Pullman, growth and yields of Fielder spring wheat in 1976 was poorer under a no-till system and, although take-all was present in the Pullman plot, and was most common in the no-till areas, the total amount of take-all in the Pullman spring wheat plot was too low to account entirely for the poor growth with no-till at that location.

An interesting observation on plant nutrition has been made in the Lind trials. Plots received one of three fertilizer soil-treatments, each of which supplied 150 lbs N per acre. Plants fed a "complete" fertilizer containing nitrogen, sulphur, phosphorus, potash, zinc, boron and molybdenum, were twice as vigorous as plants that received only nitrogen and sulphur. The response was evident in all plots, but was particularly striking in fumigated soil from which disease agents had been eliminated. We believe the response is entirely nutritional. The significance of this observation to commercial wheat production is not known because the soil where the response occurred has been continuously recropped to wheat for 10 years. A third "fertilizer" soil treatment, chicken manure, produced plants with a vigor superior to the inorganic N + S treatment, but somewhat below that of the "complete" fertilizer.

SOIL FUMIGATION FOR WHEAT

R. J. Cook

Trials with soil fumigation to eliminate diseases of wheat are underway for the third consecutive year at Lind, and also at several locations in the Pullman area and in adjacent Idaho. The major objective is to use fumigation as a tool to help reveal the existence of soilborne disease organisms. By eliminating these organisms, some not yet identified, we hope to learn more about the true growth potential of existing wheats under modern-day management practices.

The fumigants used this year include replicated trials of chloropicrin (400, 100, 50 or 25 lbs per acre, depending on the site and trial); Telone II at 20 or 25 gal per acre; and Telone IIC (a mixture of Telone plus 17% chloropicrin) at 20 or 25 gal per acre. These fumigants are all injected by machine. In addition, several fumigation trials have been established on no-till plots using 400 lbs methyl bromide per acre applied under a plastic tarp without disturbing the soil in the plot area.

The most conspicuous responses of wheat to soil fumigation include (1) greatly increased tillering, (2) 2-6 inches greater height at heading, and (3) up to 1 week earlier heading. This response occurs with chloropicrin at 100 lbs or more per acre (results not yet available for the 50- and 25-lb rates) and with Telone IIC, but not with Telone II alone. Possibly the response is due to elimination of a soil organism that reduces tillering and plant height and delays heading. Organisms known to have this effect on wheat are currently under study. We have made detailed microbiological studies of fumigated soils over the past 3 years and have ruled out many suspects, but have not yet identified with certainty which organisms are responsible for the "symptoms" eliminated by soil fumigation.

At Lind, the trials are on land in irrigated wheat for the 10th consecutive year. The wheat was severely damaged by take-all in 1975 and again in 1976. Either chloropicrin at 100 or more lbs per acre, or Telone IIC, but not Telone II controls take-all based on results to date. Last year, yields were 35-40 bu/A without fumigation and 90-100 bu/A with chloropicrin. This year (1977) is the first test at Lind with Telone materials and, although preliminary data on disease are already available, yield data are not yet available. Unfortunately, at Lind we can find no evidence for carry over benefits of fumigation, i.e., the response one year does not occur in that plot the second year without refumigation.

Part of the low yield of wheat in the Lind irrigated-wheat plot may relate to an undiagnosed nutrient deficiency (see report in this brochure, *Effect of No-Till on Take-All of Spring and Winter Wheat* by K. J. Moore and R. J. Cook).

Much interest now exists in the annual-cropped area of eastern Washington and adjacent Idaho to produce wheat without tillage (no-till) and thus obtain better control of soil erosion. However, there is a "wheat sickness" problem in no-till and not apparent with tillage that shows up as small yellow plants beginning at the seedling stage. Weeds then get ahead of the crop. Soil fumigation eliminates the wheat sickness problem in no-till which is good evidence that the problem is due at least partly to soil microorganisms. Our fumigation plots indicate that there is no physical restriction of wheat growth by the heavy straw residue on the soil surface. Soil moisture availability with recrop is apparently even better with no-till and this is especially apparent at Pullman in this year of severe drought. Studies are underway to determine the role of specific soilborne pathogens in the wheat sickness problem in no-till in the Palouse.

SPRING WHEAT IMPROVEMENT

C. F. Konzak, M. A. Davis, M. Wilson, Pullman
E. Donaldson, M. Nagamitsu, Lind, Collaborators

The spring wheat research in Washington is conducted utilizing the research facilities at Pullman (medium rainfall), Lind (low rainfall), and Royal Slope in the Columbia Basin (irrigated). At these locations new varieties, lines, and plant selections are being tested in preliminary nurseries with each entry being evaluated at all three 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.

Among the nurseries grown at the three locations, several can be seen by those attending the field days, including the Regional Facultative Wheat Nursery and the combined Western Regional and State Uniform Spring Wheat Nursery. The Midwestern Uniform Regional Hard Red Spring Wheat nursery is grown only at Lind while the International Spring Wheat Nursery (CIMMYT) is grown at Pullman with observation plots grown at Lind. The main crossing blocks and parental lines are grown at Pullman, and virtually all crosses are made at that location because of the more favorable conditions for crossing and regular adaptability of new parental sources.

The general scope of WSU spring wheat research is indicated in Table 14, which lists the trials and numbers of selections under evaluation in 1976 and 1977. 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 single lines. Research to improve the potential for higher content and nutritional value of the protein in hard red wheats is receiving increased emphasis. Preliminary yield tests of some higher protein derivatives from crosses between local and Argentine wheats are included in the 1977 research at the three main WSU station sites.

The 1977 Western Regional and Washington State Spring Wheat Nurseries include new varieties from the Washington State cereal research program and the states of California, Idaho, Oregon, Minnesota and Utah as well as promising new entries from private breeders.

Results of the 1976 season's tests provided further evidence of advances in yield potential among WSU-developed spring wheats and yields above 90 bu/A were recorded in replicated tests at Pullman (with Fielder about 65 and Wared about 60 bu/A), the season also provided some unpleasant surprises. Abundant leaf and stripe rust, including the presence of some new races, played havoc, possibly eliminating many promising high yielding lines from competition to become varieties, and relegating them to a role as germ plasm. Among the soft white wheats, Fielder and the proposed future sister selection release, Fieldwin, showed susceptibility to a new race of stripe rust. The general type of resistance of Urquie was still highly effective. In fact, Urquie performed exceptionally well overall in 1976. The red wheat fared better to stripe rust and leaf rust but more stripe rust than in previous years was observed on Wared and the proposed Idaho release Sawtell. Although Fielder, Wared, and Sawtell appear to have some leaf rust resistance, their response to the new race affecting Hyslop is not clear. Wared appears to have non-specific resistance. Twin and Urquie are fully susceptible to most leaf rust races. It is probable that the facultative lines in advanced testing also will be susceptible to the new race, although they have high resistance to the previous leaf rust population.

The cooler, wetter than usual 1976 contributed favorably to the highest spring wheat yields ever recorded from replicated experimental plots at Pullman, with generally high average yields recorded also in the low rainfall area tests at Lind and in irrigated trials at the Royal Slope research unit. Maximum potential of the spring wheats was not achieved at any station, however. At Pullman, late-appearing stem and leaf rusts reduced yields to some extent on the later maturing susceptible wheats–their maturity in 1976 delayed not only by the cool season, but also because the earliest plantings were made in May due to wet cool spring weather. Later than desirable planting at Lind also affected the potential yield expression of many wheats. At Royal Slope, yields above 100 bu./acre were common, but the crop appeared to have the potential for 50% greater yield. Take-all disease was one factor in the reduced yields, but also it was likely that the high aphid population coming over from the sugar beet fields reduced yields significantly. It is anticipated that the 1977 crop at Royal Slope will not meet the same problems, and at this date there seems promise for very high expression of the yield potentials of selections being tested there.

VARIETY DEVELOPMENT

URQUIE–Developed at Washington State University with cooperation of USDA-ARS and released by Washington and Idaho in 1975 as a replacement for Marfed. This new high milling and baking quality common soft white semidwarf spring wheat variety carries an effective mature plant type of resistance to stripe rust. Urquie also produces better test weight grain than Twin under virtually all cultural conditions. Earlier tests indicated that Urquie was better adapted to the low rainfall areas than either Fielder or Twin. Tests in 1976 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. Supplies of Registered Seed will be available via WSCIA for 1978 planting.

WALLADAY–Increased in 1976 as WA6101. This semidwarf, soft white common spring wheat probably will be released in Fall 1977. Walladay carries resistance to some races of leaf rust and is moderately resistant to stripe rust. Its quality is similar to Nugaines. Yield performance in tests to date indicate that Walladay has equal to greater potential than Fielder. Its later maturity than Twin or Fielder may permit higher yield potential under irrigated culture. Walladay appears to have 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. A small Foundation and additional Breeder Seed stock increases are in production in 1977.

WA6153, WA6246–These spring Luke mutants are semidwarf common white spring wheat lines under consideration as candidates for selection of possible Breeder Seed stock. These are some of the higher yielding induced spring habit mutants from Luke Winter Wheat. They appear to have better milling and baking quality properties than Twin, Walladay and possibly Fielder. These lines are later maturing than Twin, Fielder or Urquie, but are in about the same maturity class as Walladay. Their facultative performance (from fall and spring seedlings) appears especially promising. Their disease resistance is similar to that of Luke, but they are earlier maturing than Luke from fall plantings. They may be useful for fall sowing in certain areas of Northeastern Washington, and for spring sowing in other areas of the state.

HARD RED SPRING WHEATS

SAWTELL—Formerly ID000047, a semidwarf hard red spring wheat developed by the USDA-ARS 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. In 1976 Sawtell was moderately susceptible to stripe rust at Pullman, so it may be susceptible to the stripe rust that attacks Fieldwin.

WAMPUM—Formerly WA6105 developed by Washington State University with USDA-ARS 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 Breeder seed are being produced in 1977.

WA6109—Under preliminary increase to be considered for possible variety development. This semidwarf hard red spring wheat has excellent milling and baking quality properties, and has different and possibly more broadly based leaf and stripe rust resistance as well as good mildew resistance. Its yield performance has been variable, but equal to Wared on average. It seems better adapted for production under irrigated than low rainfall conditions.

Barbee, a new soft white club variety

Table 14. Research Trials and Number of Selections Under Test in W.S.U. Research

Nurseries	Coordinator	1976 Locations ( )		1977 Locations ( )		1976 Entries	1977 Entries
Cooperative Trials–							
Western Regional Spring Wheat Nursery	USDA-MT	25	(3)	25	(3)	30	28
Western Facultative Wheat Nursery	WSU	9	(5)	12	(6)	16	24
Tri-State Spring Wheat Nursery (WA, ID, OR)	WSU	6	(3)	7	(3)	20	35
International Spring Nursery	CIMMYT-Mex	60	(1)	60	(0)	50	not. avail.
International Durum Yield Nursery	CIMMYT-Mex	27	(1)	27	(1)	25	25
International Durum Elite Nursery				12	(1)		50
International Spring Wheat Observation Nursery	CIMMYT-Mex	40	(1)	60	(1)	300	300
International Winter/Spring Wheat Observation Nursery	CIMMYT-OSU	25	(1)	25	(1)	450	450
WSU Research Trials–							
Private Breeders Selection Nursery	WSU		(3)		(4)	16	25
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	100
WSU Preliminary (1st season rep)			(3)		(3)	450	320
WSU Single Plot (4-row)			(3)		(3)	650	1100
F_4 - F_5 Single Row Evaluations			(1)		(1)	20000	25000
F_3 Bulks (4-row plots 20' long)			(1)		(1)	400	600
High protein lines - single rows			(1)		(1)	1200	2500

( ) Number of Washington State Locations

FACULTATIVE (COLDHARDY) SPRING WHEAT BREEDING

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

Coldhardy spring wheats are now in their third year of regional testing in the states of Washington, Oregon and Idaho. All of the lines in the past three years' trials have been WSU selections. However, lines from the OSU-CIMMYT program are among those in preliminary tests. The best of these will be considered for the 1978 fall and spring Facultative Wheat Trials. Spring Luke mutants WA6152, WA6153 and WA6246 appear to be among the more noteworthy of the advanced lines under test. Facultative wheats are expected to help stabilize the production of spring wheats, and permit growers greater planting date flexibility, while hopefully helping to advance yield potentials.

Yield performance data on some of the better lines and standards from the 1976 fall and spring sown trials are shown in Tables 15 and 16.

Mr. M. R. Khajehpour from Iran, conducting graduate research on an Iranian government fellowship is studying the developmental and other traits of facultative as compared with standard winter and spring wheats, under low and medium rainfall and irrigated conditions, with two planting dates at Pullman. The later test site is on the Palouse Conservation Farm.

Table 15. 1976 Facultative Wheat Yields (Fall Seedings)

	Location Yields–Bu/A						
Variety	Pullman	Walla Walla	Dayton	Lind (Dry)	Lind (Irrig.)	Pendleton	Corvallis
Nugaines (Ck)	63	104	84	36	72	71	101
Luke (Ck)	71	112	84	34	84	68	78
Urquie (Ck)	(13)Wk	104	74	37	78	61	110
WA6100 Norco Sel.	66	92	71	35	71	64	136
WA6101	60	101	74	36	(60)	69	157
WA6153 Luke Mut.	85	104	77	38	75	67	133
WA6246	71	109	88	34	(63)	70	137

( ) 2 Poor Plot Replicate
Pullman 1976 Fall–Severe erosion of plots

Table 16. 1976 Facultative Wheat Yields (Spring Seedings)

Variety	Location Yields–Bu/A							
	Pullman	Walla Walla	Pomeroy	Dayton	Lind (Dry)	Royal Slope	Pendleton	Corvallis
Twin (Ck)	76	63	72	54	28	85	40	50
Fielder (Ck)	78*	65	67	54	---	105*	38	56
Urquie (Ck)	78	53	67	50	26	100	36	43
WA6100	81	51	78	50	25	94	32	53
WA6101	85	57	69	57	28	104	34	52
WA6153	85	52	61	55	27	99	32	58
WA6246	94	61	76	54	26	102	37	50

*Fieldwin at some locations.

Daws, a new soft white common wheat variety

TRI-STATE SPRING WHEAT NURSERY

C. F. Konzak

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

PRIVATE BREEDERS SELECTION NURSERY

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

In 1976 a new test was initiated to evaluate promising new materials 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 1976 nursery was grown at the three main station sites, and results obtained are as shown in Table 17. Unfortunately we did not include as many standards as might have been desirable but these have been included in the 1977 trials.

The 1977 nurseries include selections from three private breeders—World Seeds, Northrup-King, and Germains. In 1978 we also expect to have materials developed by North American Plant Breeders. Some of their lines are being observed at Pullman in 1977. Growers attending the Field Days at any of the three main stations will be able to observe and compare private as well as publicly developed wheats.

Table 17. 1976 Results, Private Breeders Variety Trial

Variety	Stripe Rust (Plmn)	Mildew (R.S.)	Plt. Ht. (R.S.)	Yield in % Check (Actual Yield) Lind	Pullman	Royal Slope
Red						
Wared	7/50	R	36	100 (22)	100 (64)	100 (109)
Borah	7/20	MS	32	87 (19)	117 (75)	96 (104)
Sawtell	6/30	S	34	121 (27)	100 (64)	86 (93)
Prodax	7/40	MS	32	72 (16)	108 (70)	90 (97)
Prospur	7/30	MR	36	75 (17)	122 (79)	103 (112)
Protor	5/20	MR	32	---	114 (73)	89 (97)
Profit 75	3/20	MS	34	53 (12)	116 (76)	76 (83)
W.S. 6	3/20	MS	32	71 (16)	116 (75)	83 (90)
W.S. 25	2/10	S	32	53 (12)	119 (76)	85 (93)
NK 5507	6/30	MS	34	90 (20)	107 (70)	95 (103)
NK 5509	7/60	MR	32	71 (16)	98 (63)	98 (107)
NK 5511	7/50	MR	36	68 (15)	105 (67)	106 (115)
White						
Marfed	8/30	S	42	86 (19)	88 (57)	92 (100)
Urquie	6/30	S	32	107 (24)	113 (73)	95 (103)
Fieldwin	7/20	MS	36	94 (21)	112 (72)	111 (121)
W. S. 1	6/30	MR	32	87 (19)	118 (76)	109 (113)

IMPROVING PROTEIN CONTENT AND NUTRITIONAL COMPOSITION

C. F. Konzak and N. V. Mung

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 acid (including lysine) have been identified. Some preliminary selections are now being tested for stability and adaptation in unreplicated 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 quality wheats, hence the early crosses have little potential. Thus, several breeding cycles are necessary in order to exploit the potential of these materials in developing competitive 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.

WESTERN REGIONAL SPRING WHEAT NURSERY

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

This cooperative research trial of spring wheat performance potential and adaptation usually includes 25 to 30 entries, some soft white, a few or no hard white and a high proportion of hard red spring wheats. The same nursery is grown at about 25 locations throughout the West, ranging from Canada to Arizona. WSU's 1977 entries include a soft white and four hard red spring wheat selections.

Included along with this nursery at most 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.

Breeder seed of WA6105, a hard red spring wheat, was increased in 1976 and the selection was recommended for release in 1977 and named Wampum. The soft white wheat WA6101 has been recommended for release in 1977 and named Walladay (see variety development).

Washington did not join Idaho in the release of Fieldwin because a new race of stripe rust that is able to severely damage Fieldwin and Fielder, appeared in 1976 in Eastern Washington.

WA6109 is currently under preliminary increase (see variety development). Other especially promising lines include WA6305 and WA6389 among the hard red wheat, and WA6325, WA6276 and WA6277 among the soft white wheats.

Two new dual purpose quality type wheats are included in the trials this season. These are WA6209 and WA6371, sister selections from the same cross. These white spring wheat lines appear to have good bread making properties including mixing strength, and apparently also acceptable pastry making properties (see wheat quality section).

Results from spring wheat regional trials conducted over the past three years are indicated in Table 18. The 1976 yield performance data for new varieties and comparable standards are presented in Tables 19 and 20.

Table 18. Comparison of Soft White Spring and Hard Red Spring Varieties at 6 Locations in Washington. 3-Year Average (1974, 1975, 1976).

Location	Fielder	Fieldwin	Urquie	Walladay	Wared	Borah	Sawtell	Wampum
Pullman	49.1	52.5	48.5	50.3	42.3	46.0	44.9	46.6
Pomeroy	58.2	58.8	54.9	57.9	51.3	51.6	54.5	55.0
Walla Walla	40.6	43.8	44.5	46.4	46.8	46.2	41.4	41.4
Lind	23.3	24.1	24.8	24.3	23.8	21.5	26.9	23.5
Harrington	25.7	26.7	26.0	22.5	24.1	23.2	26.7	24.3
Waterville	33.9	34.0	34.9	32.9	31.6	28.2	35.7	33.0
Average	38.5	40.2	38.8	39.1	36.7	36.1	38.2	37.1

Table 19. Regional Soft White Spring Wheat Yields for 1976.

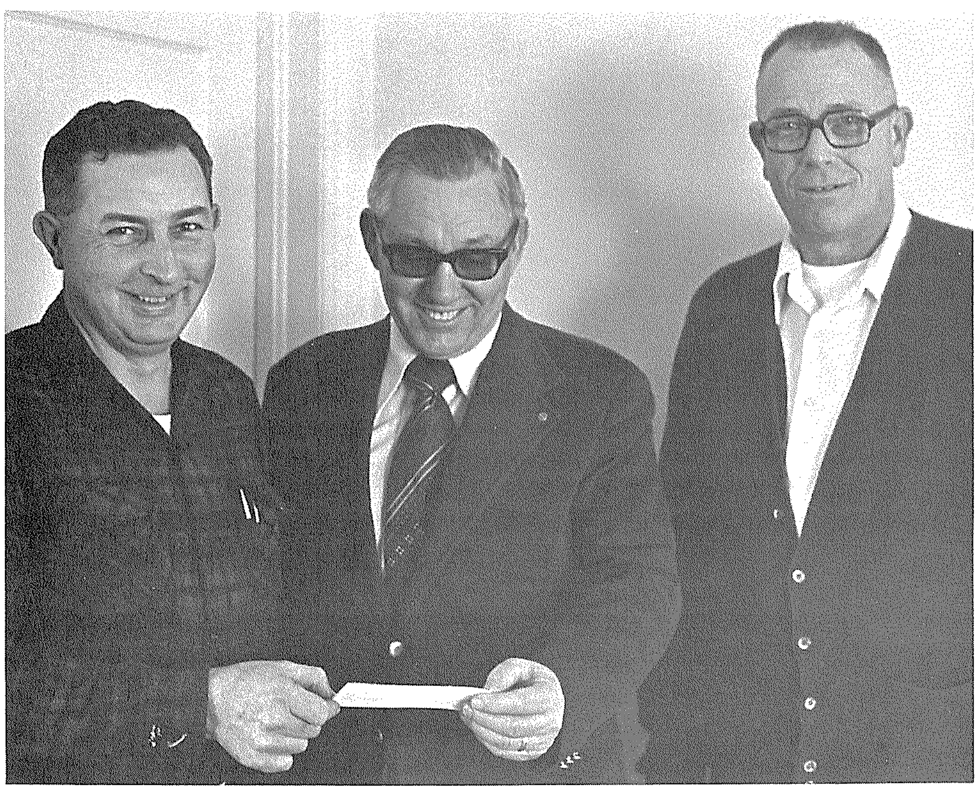
Location	Fielder Yield	(T.W.)	Fieldwin Yield	(T.W.)	Urquie Yield	(T.W.)	Walladay Yield	(T.W.)
Pullman	71.6	(59.1)	66.5	(59.6)	65.6	(58.7)	78.4	(60.2)
Pomeroy	70.7	(58.8)	71.7	(59.4)	69.2	(57.9)	68.5	(55.6)
Walla Walla	55.1	(57.3)	62.9	(58.4)	62.4	(55.5)	66.2	(57.4)
Dayton	51.5	(55.6)	54.0	(56.6)	51.9	(55.7)	55.1	(54.9)
Royal Slope	101.0	(59.4)	97.0	(58.9)	100.6	(60.1)	98.6	(57.9)
Waterville	50.7	(61.8)	47.9	(62.1)	49.4	(62.5)	44.8	(61.2)
Harrington	29.0	(59.3)	27.7	(59.6)	28.7	(59.2)	22.0	(57.8)
Horse Heaven	10.4	(53.9)	11.3	(55.8)	10.4	(55.2)	----	----
Connell	20.9	(58.8)	20.2	(59.5)	23.2	(58.0)	----	----
Lind	21.0	(57.7)	20.4	(58.6)	19.1	(57.9)	20.0	(56.3)
Weighted Average	56.3	----	56.0	----	56.8	----	56.7	(57.6)
Regional Average	48.2	(58.7)	48.0	(58.6)	48.1	(58.1)	----	----

Table 20. Regional Hard Red Spring Wheat Yields for 1976.

Location	Wared Yield	(T.W.)	Borah Yield	(T.W.)	Sawtell Yield	(T.W.)	Wampum Yield	(T.W.)
Pullman	58.4	(58.5)	70.2	(59.3)	59.2	(58.0)	64.4	(58.8)
Pomeroy	66.6	(59.7)	65.7	(59.5)	65.5	(58.3)	72.1	(57.5)
Walla Walla	60.3	(57.5)	63.9	(57.6)	54.7	(55.4)	64.7	(58.6)
Dayton	54.1	(55.9)	52.6	(57.3)	56.9	(55.5)	55.7	(56.1)
Royal Slope	70.4	(56.2)	68.9	(56.2)	56.6	(52.3)	88.2	(57.4)
Waterville	46.1	(63.7)	42.1	(62.0)	49.6	(62.5)	44.1	(61.6)
Harrington	28.4	(60.4)	24.9	(60.5)	29.5	(58.9)	27.7	(58.2)
Horse Heaven	8.3	(56.0)	10.9	(55.3)	8.3	(53.2)	10.3	(53.2)
Connell	22.5	(57.2)	18.7	(58.5)	23.4	(58.5)	21.3	(56.2)
Lind	21.8	(58.5)	18.4	(57.8)	24.3	(57.1)	20.8	(56.7)
Regional Average	43.7	(58.4)	43.5	(58.4)	42.8	(56.8)	46.9	(57.4)

Table 21. Observation nursery yields of soft white spring wheat for 1976.

Location	Fielder Yield	(T.W.)	Fieldwin Yield	(T.W.)	Urquie Yield	(T.W.)	Walladay Yield	(T.W.)
Lamont	30	(58)	26	(59)	25	(58)	26	(55)
St. John	56	(58)	48	(58)	60	(57)	63	(58)
Dusty	32	(56)	35	(58)	40	(57)	44	(56)
Farmington	41	(56)	45	(54)	34	(51)	40	(53)
Uniontown	41	(55)	42	(57)	51	(57)	54	(54)
Asotin	36	(55)	37	(56)	32	(56)	29	(54)
Addy	60	(57)	68	(58)	54	(56)	62	(58)
Mayview	61	(61)	64	(61)	53	(58)	51	(59)
Observation Average	45	(57)	46	(58)	44	(56)	46	(56)



Norm Heitstuman presenting Ken Morrison and Felix Entemmann a cash contribution for research.

Table 22. Observation Nursery Yields of Hard Red Spring Wheat for 1976.

Location	Wared Yield	(T.W.)	Sawtell Yield	(T.W.)	Wampum Yield	(T.W.)
Lamont	29.3	(57.4)	32.0	(57.9)	26.6	(58.0)
St. John	61.2	(57.8)	49.6	(57.3)	69.3	(56.8)
Dusty	35.6	(56.7)	40.7	(56.0)	41.1	(56.6)
Farmington	44.0	(57.2)	39.6	(56.8)	56.0	(58.5)
Uniontown	52.0	(55.0)	45.1	(58.1)	60.1	(57.5)
Asotin	33.3	(55.0)	33.2	(56.7)	37.9	(53.6)
Addy	60.2	(58.0)	60.4	(56.7)	59.2	(55.1)
Mayview	33.4	(60.6)	33.3	(59.3)	38.0	(60.6)
Observation Average	43.6	(57.2)	41.7	(57.4)	48.4	(57.1)

DEVELOPMENT OF MORE EFFICIENT WHEAT VARIETIES

R. E. Witters

During the past few years in-depth growth analyses have been performed on several lines of both winter and spring wheat. These analyses have consisted of season-long measurements on such plant characteristics as: plant height, leaf area, plant dry weight, kernel development, number of tillers, soil moisture use, etc. The objectives have been to enhance our understanding of how wheat plants develop progressively through the season. With this information wheat breeders will have greater insights about how to select plants that will have greater capacity to produce grain. In other words, this information should help to improve the wheat breeders "mind eye" of what a plant will look like that has the greatest yield potential and yet is highly water-use efficient.

Research results indicate that the stage of maximum numbers of tillers (late April) occurs prior to maximum leaf area development (late May). In addition, most of the soil water extracted by the plants is used shortly after the stage of maximum tillering until the leaf area of the plants begins to decline. It is also apparent that the initiation of the grain-filling period takes place after about 50% of the tillers have been sloughed off and during a period where leaf area and root activity are on a rapid decline. In fact, it is not uncommon that at the time when storage materials are being accumulated most rapidly, in the kernels, only about 15-30% of the leaf area remains on the plant and soil moisture uptake by the plants is often less than 25% of its peak rate.

Consequently, with relatively little leaf area and root activity during the time of rapid grain-fill, the design of present plant types have evolved systems that are geared more for mere survival of the species, than for maximum grain production. Thus, it behooves us, as wheat researchers, to select wheat plants that place a greater emphasis on maximizing grain development than do present varieties of wheat.

Following are some growth patterns in wheat that if put together in a single variety would place greater emphasis on grain production not merely survival of the species by taking advantage of our present wheat growing environments. First, the maximum number of tillers could be reduced (at least in many growing areas), thus economizing on the use of minerals and soil moisture. Also, most varieties produce too much leaf area (at peak growth) and consequently deplete much soil moisture during a time when assimilates produced in the leaves are not being translocated to the developing kernel. Thus, if less total leaf area was produced by each plant, but more viable leaf tissue was retained on the plant for a longer time during the grain-filling period, it is likely that more assimilates would be moved into the developing kernels. The reduction in leaf area and tillers should significantly reduce soil-water-use prior to grain-filling and thus provide the roots with a better moisture supply while grain is produced.

Finally, plant breeders should put more emphasis on the selection of plants that maximize the duration of grain-fill (i.e., the number of days from heading to maturity). Apparently the wheat plant has a limited capacity to move assimilates from the leaves and stem to the developing kernel at any given time. Therefore, it will be necessary to develop wheat types that increase the number of days that kernels are being developed—within the constraints of each environment where wheat is grown.

In summary, wheat varieties of the future will have a developmental process that places much greater emphasis on maintenance of their leaves and roots for a longer period in the growing season and thus provide maximal opportunity for the plants to accumulate dry matter in the grain.

MILLING AND BAKING QUALITY
USDA, ARS, WESTERN WHEAT QUALITY LABORATORY

G. L. Rubenthaler, P. L. Finney, J. S. Kitterman, H. C. Jeffers,
P. D. Anderson, S. A. Boehme, L. J. Gray

Milling and baking quality was determined in cooperation with State and Federal scientists working on wheat improvement in the Western States. A total of 324 (36.0%) of the 908 progenies tested were rated as having promising overall quality for their appropriate market classes.

Milling quality of 2,000 early generations (F_4 and F_5) selections from the 1975 crop was evaluated on our semi-micro (150-200 g) modified Brabender Quadrumat system. The flours from the selections which appeared to have promising quality were further evaluated to estimate their baking quality for either pastry or bread products depending upon their class. The tests used for this work included protein, mixograph, and AWRC. Of the 2,000 selections, 669 (33.5%) were rated as promising in overall quality characteristics.

Protein determinations only were made on 477 hard red winter early generation progeny, and 5 g. micro milling tests were determined on 803 F_3 selections.

An extensive literature review was made in the area of biochemical and nutritional aspects of germinated grain. More than 200 articles have been abstracted and compiled as basis for investigations into more efficient use of wheat, of other cereals, and oil seeds in food products through a germination step. Germination (malting) studies are underway to find optimum conditions to prepare malt for baked products. Many of the B vitamins and lysine have been reported to increase significantly during germination. Work is directed to minimize diastatic (amylase) activity, and stimulating lysine synthesis. Temperature, water, time, and steep nutrients are being studied. Commercial maltsters strive for high diastatic activity, which limits the amount of commercial malt which may be used to less than .5%. Preliminary experiments have demonstrated as much as 50% of the flour can be replaced by laboratory prepared malts. High concentrations of malt offer the following advantages when added to bread: No sugar is required in the formula; lysine and numerous vitamins are increased; significant increases of fiber are added to the diet; phytic acid content of the bran is reduced (less interference with the mineral electrolyte balance); It imparts a desirable flavor.

QUALITY FACTORS AS AFFECTED BY PLANT PHENOTYPE

G. L. Rubenthaler, R. E. Allan, P. L. Finney, J. S. Kitterman, and H. C. Jeffers

Investigations were made using wheat isolines (lines made to differ by only one controlling gene) of several genetic backgrounds differing for plant height, awn expression, spike type, and reaction to stripe rust, to determine the influence these plant phenotypes have on end-use quality. The following is a summary of the specific relationships found among these traits with milling and flour quality characters.

PLANT HEIGHT

Isolines of Omar, Burt, Itana, Brevor, and Nord were made to differ in plant height by crossing with a one- or a two-gene source for dwarfing. Five or ten replications of each population were studied for milling and baking quality characteristics in an effort to find correlations between these characters and the three height phenotypes. Test weight, flour yield, and milling score were best in the tall sibs in all but the Brevor populations. Similarly, flour ash was lower in all populations but Itana. Water absorption increased with height in the Itana sibs, decreased with height in the Nord's, and no differences were expressed in the other Isoline populations. No baking characters for cookies or bread appear tied with the height expression.

AWNED VS. AWNLESS

Awnless expressions were also studied in the Burt and Brevor populations along with height level. Differences were noted in these backgrounds; awnless Burts were lower in test weight and flour yield and higher in flour ash while the awnless Brevors were distinctly lower in flour ash and thus better in overall milling score than the awned counterparts.

LAX VS. CLUB HEAD

In three populations studied for lax vs. club head using Suwon 92, Selection 14, and Burt as the source of the lax gene and Omar and Albit as the source of the club gene, test weight was consistently higher by .5-1.0 lbs. in the club siblines. All other factors measured appeared inconsistent with the head expression and very similar whether lax or club.

RESISTANT VS. SUSCEPTIBLE STRIPE RUST

Resistant and susceptible stripe rust sibs of Omar within the two-gene, one-gene, and normal height levels showed the susceptible to be 1-3 lbs. less test weight, equal in flour yield, but overall poorer in milling due to higher flour ash than the resistant lines. Viscosity was also notably lower 10-18 Units) in the susceptible sibs at all height levels. Viscosity was lowest in the one- and two-gene dwarfs.

DUAL PURPOSE QUALITY

G. L. Rubenthaler and C. F. Konzak

While dual purpose (bread and pastry) quality within a given wheat variety does not denote anything new, as several old varieties such as Federation and Baart possessed the ability to make both bread or pastries, little effort has gone into breeding for this characteristic. Increasing evidence has suggested that protein strength properties per se has little influence on pastry properties, but is important in breadmaking for loaf volume, and structure. Since it has been routine to only evaluate soft wheats for pastry products and hard wheats for bread production any selection with dual purpose properties would be overlooked. This past year, about 400 selections derived from soft x hard wheat crosses were evaluated by both bread and pastry tests. The objective was to determine if specific properties usually associated with only soft or hard classes of wheat could be recombined in a single line which would serve as a dual purpose wheat.

Ten selections were identified as having these dual properties for both pastry and bread products. Most of these lines baked bread as well as the Wared standard; all had stronger protein and higher water absorption than the soft white standards; and had cookies similar to the soft standards. Dough mixing properties were typical of hard bread wheats, but their milling and flour texture are similar to soft wheat. Three of the lines are sister selections, one other is related to these by one parent, while the others were totally unrelated.

These selections have been seeded and will be further tested. We are particularly interested to know if they will be satisfactory in oriental noodles and sponge cakes. Dual purpose wheats would have a distinct advantage in the market place and the approach offers a new potential and direction for wheat breeding.

BARLEY BREEDING AND TESTING PROGRAMS IN WASHINGTON

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

Washington growers produced 21 million bushels of barley in 1976 on approximately 400,000 acres for an average of 54 bushels per acre. This is well above the 1966-68 average of 44 bushels per acre.

The barley improvement program in the State of Washington consists of an extensive breeding program at Pullman involving the improvement of five different types of winter and spring, malting and feed barleys, selection and testing programs at Lind (dry land) and Davenport (winterhardiness), and testing sites at Royal Slope (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 23. This table also includes some advanced selections which will be discussed below.

The following are brief descriptions of progress towards new and improved varieties for the different types of barley produced in this State.

Spring, 6-Row, Non-Malting

The most promising replacement for Steptoe appears to be among certain selections from Steptoe x Blazer crosses. These are extremely high yielding, have better straw strength than Steptoe and most likely have improved nutritional value. Other crosses have been made to improve the protein and lysine content, yellow dwarf and greenbug resistance, and malting quality in Steptoe and other high yielding spring-type selections.

Spring 6-Row, Malting

It is recognized that Blazer, our new 6-row malting barley, does not meet all the malting specifications required by industry. At the present time we are analyzing carefully some advanced reselections out of an earlier selection, WA6591-69. These reselections are shorter strawed and higher yielding than Blazer, are considerably earlier in maturity, and have the quality of Larker. They are not quite as high yielding as Steptoe. However, they do represent progress in one of the major goals of our program, which is to develop our highest yielding varieties with malting quality so such varieties will be suitable for both animal feed and malting. It is anticipated that these higher quality barleys will be considerably better than Steptoe for livestock feed. One of these reselections, WA11312-73, is listed in Table 23 and has been under increase this winter in Arizona. The seed from that planting is now being increased in the Palouse under the control of the Crop Improvement Association.

Spring 2-Row, Malting

The Idaho variety Klages is now the standard of quality for 2-row malting barleys. We have developed progeny from crosses involving Klages that appear to be higher yielding than Klages and possess satisfactory quality. Some of these crosses involve Klages with Zephyr and a WSU Selection 8537-68.

Winter 6-Row, Malting

Our major effort here is to increase winterhardiness of our highest yielding non-malting varieties such as Kamiak and Boyer and advanced selections. We are also incorporating higher protein and lysine and yellow dwarf and greenbug resistance into these strains.

Since we are now moving towards developing the highest yielding winter genotype with malting quality, we are no longer selecting non-malting winter types for varietal release. Our aim here is to produce high yielding, winterhardy barleys that will be acceptable for industry, either as 2-row or 6-row malting types. We have early generation crosses that indicate it is possible to combine these various characteristics into one selection, and these selections are now under increase for further testing.

Considerable emphasis is being given to this phase of the program because of the significant yield advantage of 20-25%, over comparable spring types and because of the premium paid for high-quality malting barley most years.

DRY LAND AND IRRIGATED BARLEY TESTING PROGRAMS

(LIND AND ROYAL SLOPE)

Our visitors at Lind will see a number of the previously described varieties and selections in winter and spring nurseries. At the time of this writing (May 25) both nurseries were under severe moisture stress.

Under irrigation many of our new selections are performing very well. For instance, the new malting barley selection WA11312-73 yields extremely well and produces good quality under irrigation at Royal Slope. Thus, it appears that malting barley acreage, either with Blazer or with the 2-row malting barleys or with the new potential malting selection, might be profitably extended to the irrigated areas of Washington. This is important since the demand for malting barley is increasing.

PULLMAN (SPILLMAN FARM) BARLEY BREEDING PROGRAM

Visitors at the Field Day at Pullman will have an opportunity to see in demonstration plots early and late seedings of 20 current varieties and new advanced selections of spring 6-row non-malting, of 2-row malting, and of 6-row malting barleys, and 12 current varieties and new advanced selections of 2-row and 6-row winter non-malting and malting barleys. The drought stress is evident in the late seeded winter barley plot.

PROPOSED BARLEY COMMISSION

To make barley a more profitable alternate crop to wheat in this State, improvements in breeding towards higher yielding and better quality varieties both in winter and spring are imperative. Moreover, there must be much more attention given to disease resistance and to optimum cultural and management practices for attaining the potential in terms of yield and quality of our new varieties. It is hoped that these programs will be furthered (breeding and pest resistance) and initiated (cultural and management practices) through a Washington State Barley Commission. The development of this Commission was authorized by the December (1976) annual meeting of the Washington Association of Wheat Growers, and this development is being guided by a Barley Commission Committee (Steve Naught, Bickleton, Chairman). If you have any questions concerning the development and the goals of this Commission do not hesitate to ask the barley breeders during your Field Day visits to Lind and Pullman, or contact the Chairman of the Barley Commission Committee.

Table 23. Comparative Yields of Barley Types and Varieties
Pullman, 1972-76 (Lbs. Per Acre)

Spring		Winter	
6-Row			
Feed		*Feed*	
Steptoe WSU	4814	Boyer WSU	6120
Unitan	4205	Kamiak WSU	6197
		Luther WSU	5654
		White Winter	4286
Malting		*Malting*	
WA11312-73	4466	Under Development	
Blazer WSU	4200		
Traill-Larker Type	3696		
2-Row			
Malting		*Malting*	
Vanguard WSU	3994	Under Development	
Piroline	3730	Sel. 2464-70 (Ack. 989 x R.T.H.) WSU	5126
Heines Hanna	3149	Ackerman's 989	4954

OAT IMPROVEMENT

C. F. Konzak, M. A. Davis

Cayuse continues as the most widely adapted high yielding oat variety available for production in Washington. Some new selections tested in the Northwestern States Regional Oat Nursery show potential as replacements for Cayuse. Corbit, recently released by the Idaho station, has shown only similar yielding ability to that of Cayuse in Washington trials. However, WA6014 now under Breeder Seed increase has shown sufficiently greater yield potential in four years of wide scale tests to be considered for 1978 release. The name Appaloosa has been selected for this line. WA6014 showed higher barley yellow dwarf tolerance than Cayuse in cooperative tests at Davis, California. The main weakness of WA6014, like that of Cayuse is the low test weight of its grain. The grain of WA6014 can be ½ to 1 lb/bu lower than that of Cayuse. However, the slightly lower test weight may be due to its longer hull length. Five new selections identified from preliminary replicated trials in 1976 are included in the 1977 trials. All of these selections yielded more than Cayuse and had better test weight and greater barley yellow dwarf (BYDV or oat red leaf) disease versus tolerance. One of these has the highest BYDV tolerance yet obtained. All are derived from the same cross as WA6014.

Oat growers should also take special note of the hulless oat variety Terra, recently released in Canada. This variety yielded comparatively well in trials at Pullman in 1976, if the yields were adjusted for the hulls: hulless oats might prove to be especially valuable for swine and poultry feeds. Semidwarf oats possibly adapted for production under irrigation are being evaluated from preliminary increases in 1977. If they show promise replicated trials will be initiated.

The increased interest in oats for feed, appears to be such that a greater effort in oat improvement may be merited.

VARIABILITY IN SOIL MOISTURE

A. R. Halvorson

During the 1976-77 fall-winter-spring season, the dry land wheat area received about thirty percent of the long term average precipitation. This reduced level of moisture has had a marked effect on crop production. By early to mid March of this year (or for that matter, any year), it was possible to evaluate the potential wheat yield by determining the amount of available soil moisture. The amount of available soil moisture is directly related to crop yield potential. Additional spring precipitation will provide additional available moisture for crop growth—but generally 75-80% of what will be available for the crop is already accumulated in the soil profile by early to mid March.

Normally there is a variation in crop growth across a field and it is generally very evident by general observation. This year the difference was especially great and especially clear cut because in many cases moisture was the first crop growth factor to become limiting. But why the variation across the field when the amount of precipitation that fell should have been quite uniform across the field? Will moisture determinations on soil samples from these separate parts of the field show a difference in moisture proportional to the apparent crop growth?

SOIL FERTILITY MANAGEMENT FIELD TRIALS FOR WHEAT PRODUCTION

Fred Koehler, Marvin Fischer, Emmett Field, Raymond Meyer

Some 21 field trials of soil fertility management for wheat production are being conducted in 1977. They are located in 10 different counties as the nature of the questions being studied dictate. (See the map inside the front cover and the listing of grower cooperators for locations.)

Six trials in tilled vs. no-tilled systems of cultivation are being conducted in four intermediate rainfall counties. Nitrogen, phosphorus, potassium, and sulfur with different rates, materials, and placements are under comparison for both winter and spring wheats.

Other trials include nitrogen sources, rates, and times of application for spring topdressing of winter wheat; nitrogen sources, rates, and times of application for winter wheat after fallow; sulfur needs of winter wheat after fallow; nitrogen rates for winter wheat after fallow. both with and without partial irrigation; nitrogen rates and sources for winter wheat annually cropped with partial irrigation and a nitrogen, sulfur, and soil acidity long-term study with a winter wheat-dry pea rotation. One project deals with fertility requirements of winter wheat on mine spoil soils in Pierce County.

This kind of field trial program would not be possible without the willing cooperation of both the fertilizer industry and the wheat grower cooperators. Their interest and support are appreciated.

SOIL WATER STORAGE AS AFFECTED BY TILLAGE MANAGEMENT

J. Hammel and R. I. Papendick
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In recent years, great emphasis has been placed on reduced or zero-tillage systems as alternatives to conventional tillage in an effort to reduce soil erosion and to conserve energy. Less dependence on tillage for weed control due to reliable chemicals makes these systems possible. One important factor which may limit the success of reduced or zero-tillage systems in a particular area is the effect on soil moisture storage and loss because of changes in soil physical conditions. In the fallow areas, maintenance of the soil moisture through the dry summer months is essential for early fall stand establishment. Without early stands, there is a potential for less yield and increased erosion hazard. The efficiency of moisture conservation under the climatic conditions and soils of dryland areas is dependent upon the type and timing of tillage and the amount of residues on the soil surface.

Tillage plots on fallow were established in the Horse Heaven Hills and at Lind, Washington, in 1976, to compare the effects of early spring tillage with delayed tillage and chemical fallow on overwinter water storage and summertime moisture loss, and depth to moisture at fall planting. At Lind, surface residues at rates of 0, 2, and 6 T/A were superimposed on the tillage treatments. For the early tillage, the soil was worked as early as possible in the spring which coincides with the time farmers normally begin spring operations. With delayed tillage, the soil was not worked until late April, i.e., 6 to 8 weeks later. Weed control up to the time of tillage and with complete chemical fallow was accomplished with mutliple applications of glyphosate (Roundup).

At both locations, overwinter storage, oversummer loss, and depth to moisture adequate for germination at planting was not affected by tillage treatment.

Surface residues were highly effective in increasing overwinter water storage efficiency and preventing evaporative moisture loss during the summer. Overwinter moisture storage on 2 and 6 T/A surface residue treatments was 2.2 and 2.3 times higher than with no residue. In addition, the moisture content at the 6-inch depth at planting time was increased 25% in all tillage treatments with high surface residues. This additional moisture improved stand establishment by 70 to 100% as compared with the low and zero residue levels.

Delayed spring tillage would aid in the control of wind erosion during March and April when high winds commonly occur in the dryland areas. Also, the undisturbed soil would enhance deeper percolation of late spring rains, which in some years may increase overall water storage. Delayed tillage would also reduce the number of tillage operations in a wheat-fallow system.

Research on the effects of type and timing of tillage on soil moisture is being continued in the low rainfall wheat-fallow areas of eastern Washington. Meteorological data are being acquired to be used along with soil moisture data to develop a model which will predict evaporative moisture loss and seed zone moisture as a function of climate, soil type, surface residue, and tillage management.

MACHINERY AND PRACTICES TO REDUCE NON-POINT SOURCE POLLUTION

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The purpose of this research is to develop new equipment and cultural practices for growing small grains in the Palouse Region in such a way as to minimize soil erosion, operating expense, and energy requirements while maintaining net return.

Included in the work are studies of many types of seed furrow openers for no-till and reduced tillage systems, and the measurement of energy requirements of various cultural practices, as well as evaluation of the contribution of these methods toward reduction of soil erosion.

Progress to date includes the planting of four sets of winter wheat no-till plots with a modified commercial drill that could plant with twelve different combinations of implements, and a drill survey plot planted with five different drills, three of which are commercially available in some form. Stand counts and volunteer and weed counts were made and yields will be evaluated for this harvest. One set of plots of spring wheat was also planted with six implement combinations and four replicates of each. All plantings were under no-till conditions.

Opener performance in general was satisfactory. Difficulty in getting the machine through heavy, loose straw occurred with hoe-type openers or clearing shovels when they were not set between split packer-wheels. However, the hoe openers did place the seed adequately. Disk openers, while causing no plugging problems in heavy straw, failed at times to put the seed down into residue-free soil.

EROSION PREDICTION AND CONTROL

D. K. McCool and R. I. Papendick
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A continuing effort in soil and water research at Pullman is to adapt the Universal Soil Loss Equation (USLE) to the Pacific Northwest wheat region to use as a soil and crop management planning tool and to predict the effect of changes in land management on soil erosion and water quality. The goal is to make the equation reliable enough so that it can be used for establishing guidelines in design of improved agricultural practices to protect soil and water resources and control nonpoint source pollution. The USLE uses factors for rainfall and runoff, soil type, slope length and steepness, crop management and erosion control practices in computing 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 portions of Idaho, Oregon, and Washington.

An erosion survey across Whitman and Latah counties on farmers' fields and a more localized study on small runoff plots to determine the effect on erosion of slope length and steepness are part of the USLE effort. End-of-winter soil loss is measured with the rill meter, a six-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, because of low runoff, no data were collected. Preliminary results indicate that slope steepness has much less effect on erosion here than in the Midwest.

In another study, runoff plots 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 and near Rockford and Fairfield, Washington, on cooperators' land. The Rockford study is in cooperation with 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. Results indicate that critical periods for erosion in bluegrass seed production cropping systems 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 runoff, but the water is clean. Heavy erosion on cropped land can be attributed to excessive tillage and/or high fall soil moisture which limits water infiltration into soil.

A new project underway is one in cooperation with the Agricultural Engineering Department of the University of Idaho 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 management planning effort established by Public Law 92-500, Water Pollution Control Act Amendments of 1972. The major test site area is the Cow Creek Watershed south of Moscow, Idaho. Study methods include installation of runoff plots to evaluate the effect on runoff and soil loss of such treatments as divided slope and minimum tillage, rill meter measurements to evaluate erosion with conventional tillage treatments, and downstream water sampling sites to relate water quality to upstream land. The project was started in the fall of 1976, but because of the dry winter little data were collected. The only visible erosion was on fields planted to winter wheat after peas.

The 27-square mile Missouri Flat Creek Watershed just northeast of Pullman, Washington, is the test site of a study to determine the total amount of sediment transport from an intensively cultivated agricultural watershed. Additional studies include 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.

AGRICULTURAL HYDROLOGY RESEARCH

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Our nation is in the process of assessing the water quantity and quality from agricultural lands. Our hydrology research is being conducted to define the quantity and quality of water from various land uses so that decisions and recommendations by regulatory agencies for improvement of water quality and uses of water will be based on factual data and will be realistic and feasible.

Current Research:

Field data are being obtained on two pastured watersheds near Potlatch, Idaho, with the objective of defining water quantity and quality from well-managed pasture land for our national assessment and for comparison with other land uses. A grazed watershed of about 60 acres and an ungrazed check area of about 3 acres have been instrumented for measurement of streamflow, precipitation, soil erosion, water quality, soil moisture, and other variables that affect flow volume and water quality. Samples of water are analyzed for selected nutrients and bacteria. All instruments were installed during the fall of 1976 and will be operated continuously for at least 3 years.

Analyses work using hydrologic mathematical models is being initiated to further our understanding and predictability of the fate of water on agricultural fields. These results will provide guidance for better water management and will enhance our ability to control soil and chemical movement from our agricultural fields.

Future Plans:

Additional small watersheds in the Palouse will be instrumented to determine the water quantity and quality from well-managed farmland. There is a vital need to relate the water quality of major streams with upstream land use and hydrologic processes, and to seek control measures for runoff, erosion, and chemical movement that meet farming needs.

Methods to improve water infiltration into frozen ground are being developed for testing. Frozen ground runoff is some of the most serious in terms of water loss and erosion. Initial tests making use of different methods of residue incorporation in soil will be conducted on small plots at the Palouse Conservation Field Station.

CROP RESIDUE MANAGEMENT AND MICROORGANISMS

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Minimum tillage and no-tillage plantings effectively reduce soil erosion, but these systems often reduce crop yields. This is particularly true where large amounts of crop residues remain on the soil surface, such as in the center of the combine path or in low areas of the field. The plants in these areas, beginning with seedlings, are often stunted and chlorotic, and often do not respond to fertilizer applications. Toxins leached from the decaying surface residues are suspected as the cause of the problem. However, toxins produced from decomposing plant residues left on the soil surface are not the only potential consequences from this residue management system. Whenever crop residue management systems are modified, soil microbial population changes occur that can directly affect nutrient availability and the microflora associated with the plant.

Toxin Studies:

Last year, tests using seedling winter wheat indicated that water extracts of pea, lentil, wheat, barley, and bluegrass straw all produced significant amounts of root-inhibiting toxin(s) during straw decomposition in the field. The decaying legumes produced the toxin for a short time in the fall only. The other residues produced toxins in the fall and cyclically through the winter and extending into the spring. Toxins were found in straw extracts of the nonlegumes whenever the straw was set for a period of three days or more. The toxins disappeared during prolonged dry periods, were heat stable, and retarded test plant root growth only.

The toxins are rapidly deactivated in the soil, so when crop residues are managed on the soil surface it is likely the plant root must be in close proximity to the decaying straw for damage to occur. The plant growth stages where toxin damage is most likely is in the small seedling stage after germination and during tillering when secondary roots are formed.

When wheat is no-till seeded through heavy crop residues, some of the residue is pushed into the seed row. The emerging root is then in close proximity to the toxin source and injury is likely to occur. Field observations indicate injury does occur at this growth stage.

Another problem that develops with direct stubble planting is that heavy straw mat causes the wheat plant to set a high crown, sometimes as much as an inch above the soil surface. When this happens, the secondary roots emerge in direct contact with the straw and may contact the toxin. The inhibitory action of the toxin is temporary and once removed from the growing tip of the root normal growth resumes. Eventually, the root may penetrate the soil deep enough to avoid any toxin and resume normal growth, but growth has been retarded. Also, the plant can be permanently injured if water-stressed during a warm, dry spell. The application of certain herbicides during such a stress period will compound the injury.

Grain drills designed to move the residue away from the seed row would avoid placing the seed in direct contact with the straw and would allow normal crown set. Thus, the effect of the toxin on either the primary or secondary root would be minimized. A study evaluating the effects and feasibility of moving the straw away from the seed row is currently being conducted. Because of the unusually dry weather, no toxins were found in the straw residues at the critical wheat growth stages this year. Therefore, the results of moving straw away from the seed row could not be evaluated.

Results from last year indicate that tillage is not necessary to obtain good winter wheat yields. Grain yields from winter wheat no-till seeded into spring barley plots with the stubble removed equaled those of wheat seeded with conventional tillage (83 bu/A). Where the straw was left on the soil surface, yields were reduced 11 bu/A. The plants that emerged through heavy residue had stunted roots and when dry, hot winds occurred, the plants either died or were permanently stunted. The fact that residue removal resulted in good wheat yields supports the theory that toxins are responsible for the yield reductions and that moving the crop residue from the seed row will alleviate the problem. The yield reduction was not caused by low temperatures because wheat growth was normal when the crop residue was simulated by foam chips. The fertilizer and herbicide applications on all plots were identical and all grassy weeds were pulled by hand.

Sod Seeding:

No-till seeding of spring wheat into chemically killed bluegrass sod is currently being studied in the Rockford area. Preliminary results indicate grain yields from no-till seeding into spring-killed sod are as good or better than conventionally prepared seedbeds in tilled-out sod. However, no-till seeding of spring wheat into fall-killed sod resulted in reduced plant vigor and poor yields. There is strong evidence that toxins produced by the decaying fall-killed sod were responsible for the poor yield. When the sod was killed in the spring, toxin production was delayed so the seedling had established sufficient root depth to avoid injury from the toxin. When winter wheat was no-till seeded into fall-killed bluegrass sod, the wheat winter-killed, presumably mostly from frost heaving.

Microbial Associations:

Studies are underway to measure the effect of surface residue management systems on microorganisms associated with the plant root. We have found that the microbial populations on the wheat plant roots are different when crop residues are left on the surface than when crop residues are incorporated into the soil. At this time, we do not know whether this change is harmful or beneficial. We know the root microflora of a plant can influence the plant's health and the availability of nutrients to the plant.

The microbial conversion of ammonium to nitrate is being compared under conditions where crop residues are managed on the soil surface vs incorporation of residues into the soil. Presently no apparent differences have been found. It is very important to know this information because the rapidity of conversion of ammonium to nitrate is important to plant nutrition and to overwinter loss of fertilizer nitrogen.

WHEAT MANAGEMENT AND PRODUCTION

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OBJECTIVES:

The main objectives of this crop management and production program are: 1) to examine various plant types and ideotypes to characterize the most desirable traits for a specific erosion control program and, 2) to examine various management and cultural practices for growing wheat and barley in the Pacific Northwest.

ONGOING RESEARCH:

Since November, 1976 several experiments have been initiated for the coming year.

Sixty winter wheat varieties and parent lines being grown under no-till planting into pea and wheat stubble are being examined for differing growth habits. These results should lead to a better understanding of the most desirable plant characteristics for production in no-till management systems.

At Pullman and St. John, 12-spring barley, 8-spring wheat, 3-oats, and 1-triticale variety are being tested under 3-seeding rates using several planting dates.

Also, seedings of wheat, barley, and peas have been made at St. John and Pullman to initiate a crop rotation and management experiment. A number of winter wheat varieties will be examined, using several crop rotations and three tillage systems (conventional, stubble mulch, and no-till).

WEED CONTROL RESEARCH

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1. Use of herbicides in summer fallow weed control.

   Season-long wee control during fallow can be attained with herbicides alone (zero-tillage), but requires multiple applications. Satisfactory stand establishment with early seeding has been difficult in zero-tillage with present seeding equipment. Present trials are emphasizing use of herbicides to allow delay of initial primary spring tillage and reduce the number of secondary operations, yet leave a suitable seedbed for timely planting. Herbicides presently registered for this use include: atrazine (AAtrex), cyanazine (Bladex), glyphosate (Roundup), and paraquat (Ortho Paraquat). Nonregistered herbicides that are under development include: amitrol T (Cytrol-Amitrol T), metribuzin (Lexone or Sencor), PPG-135, RH 2915, and VEL 5026.

2. Effect of crop rotation on continuous no-tillage planting in annual cropping systems.

   Acceptable levels of weed control under continuous zero-tillage are possible only if alternate spring-fall cropping sequence is followed. Highest yield and best weed control have been attained where a sod crop such as alfalfa has been included in the rotation. Volunteer spring barley and other grass-type weeds are major problems.

3. Control of grass-type weeds in zero-till winter wheat.

   With adequate early fall rain to germinate winter annual grass-type weeds prior to winter wheat seeding, use of glyphosate (Roundup) or paraquat (Ortho Paraquat) gives high level of weed control. Downy brome (cheatgrass) that germinates later has been controlled with metribuzin (Lexone or Sencor) alone or in combination with other soil-active herbicides. However, safety to the wheat from this herbicide is marginal. Wild oat has been satisfactorily controlled by post-emergence applications of difenzoquat (Avenge) and HOE 23408 (Hoelon).

4. Weed control in zero-till peas and lentils.

   A three-way combination of herbicides is required to give satisfactory weed control in zero-till peas or lentils. Weeds present at seeding must be controlled with a contact material such as paraquat or glyphosate (Roundup). Later-emerging weeds can be controlled with herbicides such as metribuzin (Lexone or Sencor) or dinoseb (Sinox). The third needed ingredient is a wild oat herbicide such as difenzoquat (Avenge) or HOE 23408 (Hoelon). Yields of zero-till peas and lentils have been consistently below conventional plantings.

5. Direct seeding of bluegrass sod.

   Satisfactory suppression of bluegrass sod can be attained with two quarts of glyphosate (Roundup) applied to *actively* growing bluegrass. Peas and spring wheat have given acceptable yields when seeded directly into the killed sod.

BREEDING, DISEASES AND CULTURE OF DRY PEAS

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Agricultural Research Service
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 did not differ from Alaska in resistance to seed bleaching, powdery mildew, or mechanical damage. Garfield flowers at the 14th node and has apparent tolerance to pea root rot, two factors which should 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 should improve harvesting ease on the ridges where lack of vine has been a chronic 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. A promising Alaska type selection (WA 510-524) with earlier maturity than Garfield and showing resistance to powdery mildew bleach and *Fusarium* wilt is in the early stages of testing and seed increase. WA 510-524 is an F_8 selection from a cross between Alaska and B769-58-1, a multiple disease resistant breeding line.

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 16 pea varieties. These 16 varieties include five dry peas, ten freezer and canner peas, and one Austrain winter pea. We are now in the second backcross and plan to make a total of seven backcrosses. This project should be completed in about three years. Hopefully, the virus-resistant derived lines will be a means of preventing new 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 has been identified in the Plant Introduction collection, and it appears to be inherited as a single gene recessive. Incorporation of the resistance into commercial lentils is now underway.

Nearly 300 preliminary selections were screened for resistance to powdery mildew at Pullman. The natural infection obtained by planting late in June reached epidemic proportions at about bloom. Twleve lines showed immunity and three showed a high level of tolerance. These lines will be increased and evaluated for agronomic characteristics, especially yield, and will also be used as parental material.

Lines with pea seed weevil-resistant parentage that showed resistance to *Fusarium* wilt race 1 are being evaluated in 1977 for resistance to the insect. Hopefully, an agronomically acceptable line can be identified and used as a control measure for the insect. Work is also underway to control the pea leaf weevil through development of resistant varieties. Resistance or tolerance appears to be associated with vigorous plant types with high leaf area.

LENTIL RESEARCH, 1976-1977

V. E. Wilson and Richard Short
Agricultural Research Service–USDA

Lentil yields have not increased appreciably in 25 years. Weather and yield records indicate that seed yields declined in years when temperatures were relatively high during the flowering period of June and July. In 1973, for example, air temperatures were relatively high throughout the growing season. That year lentil yields were below the annual per acre average. Lentil flowers are highly sensitive to heat stress. And, lentils grown in the Palouse frequently flower when the average day temperatures exceed 80°F. This reduces lentil yields.

To determine effects of temperature on flowers of field-grown plants, seed yields were compared among 2 varieties and 14 experimental lines. Replicated nurseries were sown on April 30, May 7, and May 21, 1976. Flowering occurred about 55 to 60 days after sowing. Average seed yields were 1,639 lbs/A from the earliest sowing, 1,402 lbs/A from the second sowing, and 803 lbs/A from the third sowing. Average daily maximum temperatures during the flowering periods were about 75, 80 and 84°F.

During 1976, controlled temperature experiments showed that lentil lines and segregating progeny from crosses differed in their ability to develop seed at temperatures up to 80°F. Temperatures above 80°F caused total pod abortion except when the relative humidity was forced to an abnormally high percentage. As temperatures declined to about 70°F, the number of seed per plant increased. Preliminary studies strongly indicate that lentil germ plasm is available for developing lentil varieties resistant to heat stress and for increasing seed yields.

Field plots and environmental-controlled growth chambers substantiate tests that indicated lentil yields are reduced by high temperatures during flowering periods in the Palouse. Field testing high-temperature tolerant lentils will begin in 1978.

Winterhardy lentils, sown in October 1976, suffered from low soil moisture. By February, 1977, many plants had died from root rot and drought conditions. Laboratory studies showed that 27 plots or about 3% of the winterhardy experimental lines were resistant to root rots and had survived drought conditions.

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.

To give the windbreak height, a black locust is still the best deciduous tree. Green ash may also be used. Austrian pine and ponderosa pine are the outstanding evergreen trees, both being superior to Scotch pine. Douglas fir and blue spruce can be grown, but require more care and grow much slower. Rocky Mountain juniper is more difficult to establish than other evergreens, but is extremely hardy and vigorous when once established.

A shelterbelt planting requires considerable work. To survive under dry land conditions, trees and shrubs require continuous clean cultivation. Space rows between trees so available machinery can be used. Transplant trees and shrubs as soon as you get them. All evergreens require special care when transplanting. Transplanted evergreen stock has survived better than seedling stock. Although transplanted stock is more expensive, the superior survival compensates for the extra cost.

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