WSU
FIELD DAYS

June 18, 1987
Dry Land Research Unit, Lind

June 25, 1987
Integrated Pest Management Tour
Palouse Conservation Station
Pullman

July 9, 1987
Spillman Farm, Pullman

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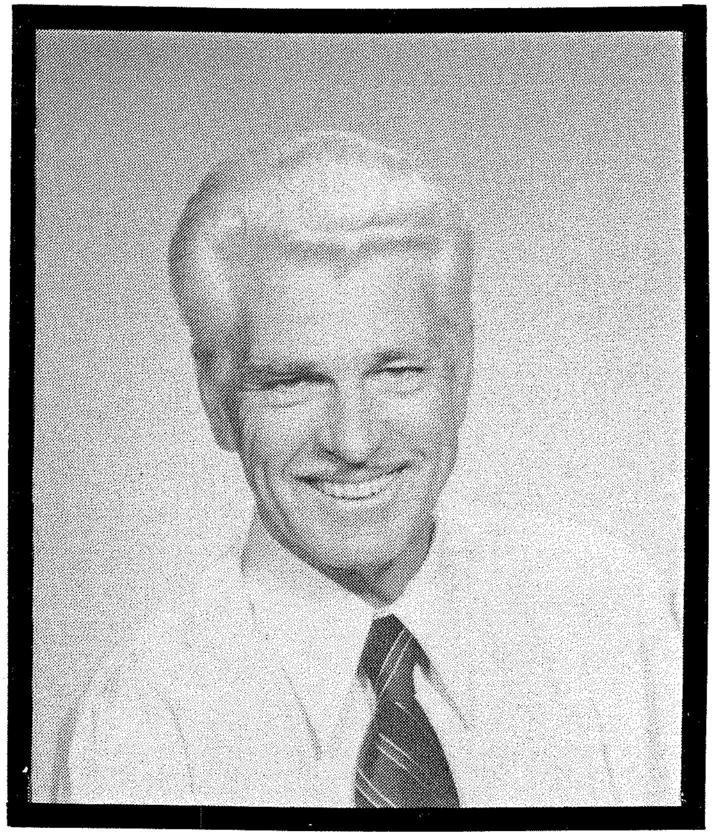
DEDICATION



It is a pleasure for the Agronomy and Soils Department of Washington State University to dedicate the Field Day brochure to Scott Hanson. Scott retired April 1, 1987 as Administrator of the Washington Wheat Commission. He worked with the Agronomy and Soils Department and other departments in the College of Agriculture and Home Economics and the USDA/ARS for many, many years. The Agronomy and Soils Department cherished the relationship with Scott.

Prior to joining the Wheat Commission he was an Agricultural Trust Administrator for Seattle First Bank, and worked for Unical Corporation as an agriculture industry executive. He also farmed. These experiences made Scott a very valuable administrator for the Wheat Commission.

Scott was born in Idaho on what he terms "the poorest farm in Madison County". He attended Gonzaga University, Whitworth College, the University of California, and San Jose State University. His wife, Barbara, is a family counselor. They have two daughters who attended Washington State University and are now doing graduate research at Denver University and the University of Washington.

Upon his retirement from the Washington Wheat Commission, Gonzaga University in Spokane employed Scott to do rural sociology research on farm community leadership development, agriculture organization development, small group relations, and farm family conflict resolutions.

Scott says he "will not stop coming to Lind Dry Land Station and Spillman Farm field days until Dr. Vogel stops coming".

The Agronomy and Soils Department hopes that both will continue to attend the field days for many years in the future.

HISTORY OF THE DRY LAND RESEARCH UNIT

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

Adams County has played an important part in the history of the station. The county donated $6000 to start the station and the land has been donated by the county. In the early 30's during the depression, Adams County kept the station alive with a small appropriation until the College could fund the operation again. In 1965 Adams County deeded 318 acres to Washington State University: two acres were previously deeded to make a total of 320 acres in the Dry Land Research Unit.

The first superintendent was the late Dr. M. A. McCall. McCall was a gifted researcher given somewhat to philosophy in his early reports. In a 1920 report he outlined the fundamental reasons for an outlying experiment station. He stated, "A branch station, from the standpoint of efficiency of administration and use of equipment, is justified only by existence of a central station." For seventy years this station has followed this policy of studying the problems associated with the 8 to 12 inch rainfall area.

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

The present facilities include a small elevator which was constructed in 1937 for grain storage. A modern office and attached greenhouse were built in 1949 after the old office quarters were burned. In 1960 a 40' x 80' metal shop was constructed with WSU general building funds. In 1964 an addition to the greenhouse was built with a Washington Wheat Commission grant of $12,000 to facilitate breeding for stripe rust resistance. In 1966 a new deep well was drilled, testing over 430 gallons per minute. A pump and irrigation system were installed in 1967. The addition of a 12' by 60' trailer house, and improvements in 1966 and 1967 amounted to over $35,000 with more than $11,000 of this from Wheat Commission funds and the remainder from state funds. In 1983 a new seed processing and storage building was completed at a cost of $146,000. The Washington Wheat Commission contributed $80,000 toward the building with the remaining $66,000 coming from the Washington State Department of Agriculture Hay and Grain Fund. A machine storage building was completed in 1985 at a cost of $65,000 funded by the Washington Wheat Commission. The old machine storage built shortly after the station was established was removed in 1985. The major portion of the research has centered on wheat. Variety adaptation, wheat production management including weed and disease control, and wheat breeding are the major programs of research in recent years. Twenty acres of land can be irrigated for research trials. The primary purpose of irrigation on the Dry Land Research Unit is not to aid in the development of hard red winter wheats for higher rainfall and irrigated agriculture, but to speed up and aid in the development of better varieties for the dryland wheat summer fallow region. Although many varieties of wheat have been recommended from variety trials by the station, Wanser and McCall were the first varieties developed on the station by plant breeding.

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

CLIMATIC DATA

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

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

Month	Temperature °F.		Precipitation		Precipitation
	Max.	Min.	1986	1987	65 years. av (in)
January	34	22	1.86	.97	1.02
February	42	24	1.30	.19	.89
March	53	32	1.43	1.03	.78
April	63	35	.65	.54	.67
May	72	42	.48		.77
June	83	45	.08		.84
July	90	52	.30		.24
August	90	50	.05		.33
September	79	45	.93		.58
October	65	38	.62		.86
November	47	29	.63		1.23
December	37	26	.61		1.27
			8.94		9.48

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.

HISTORY OF SPILLMAN FARM

In the fall of 1955, 222 acres of land were acquired from Mr. and Mrs. Bill Mennet at the arbitrated price of $420 per acre. The money for the original purchase came as the result of a fund drive which raised $85,000 from industry and wheat growers. In addition $35,000 came from the Washington State University building fund; $11,000 from the State Department of Agriculture and another $10,000 from the 1955-57 operating budget. The dedication of the new facility took place at the Cereal Field Day July 10, 1957. In 1961 the Agronomy Farm was named Spillman Farm after the distinguished geneticist and plant breeder at Washington State University in the late 1880's.

Through the dedicated efforts of many local people and the initiative of Dr. Orville Vogel, arrangements were made to acquire an additional 160 acres north of the headquarters building in the fall of 1961. This purchase was financed jointly by the Wheat Commission and Washington State University. The newly acquired 160 acres were fenced and the wetland drained: it became an integral part of the Agronomy Farm now consisting of 382 acres.

The headquarters building, which is 140 feet long and 40 feet wide, was completed in 1956. A 100 by 40 feet addition was added in 1981. In 1957 a well that produced 340 gallons per minute was developed. In 1968 the Washington Wheat Commission provided funds for a sheath storage facility, that was necessitated by the increased research program on the farm. At the same time the Washington Dry Pea and Lentil Commission provided $25,000 to build a similar facility for the pea and lentil materials. The facilities of the Spillman Agronomy Farm now range in value well over a half-million dollars.

The Spillman Agronomy Farm was developed with proper land use in mind. A conservation farm plan which includes roads, terraces, steep slope plantings, roadside seedings, and a conservation crop rotation including alfalfa and grass has been in use since the Farm was purchased.

Ray Nelson was appointed farm manager in July 1981.

ADAPTED PUBLIC VARIETIES - WHEAT, OATS, BARLEY

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

RECENTLY RELEASED WHEAT, BARLEY AND OAT VARIETIES

Kenneth J. Morrison

WINTER WHEAT

Dusty

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

Tres

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

Crew

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

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

Lewjain

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

John

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

Batum

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

Hatton

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

SPRING WHEAT

Penawawa

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

Edwall

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

Wampum

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

McKay

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

SPRING BARLEY

Advance

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

Cougbar

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

Andre

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

Belford

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

WINTER BARLEY

Hesk

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

Showin

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

OATS

Monida

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

SPRING WHEAT RESEARCH

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

General

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

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

New Varieties

Descriptions of Edwall and Penawawa were presented previously by Dr. K. J. Morrison in this issue.

New Releases for 1987

Currently in Breeder and Foundation seed increase channels are 3 new spring wheats:

1. WA7183 (Wakanz) - this hessian fly resistant soft white spring wheat was recommended for release in 1987, pending the availability of quality breeder seed stock from production in Arizona or Pullman. WA7183 also carries a combination of resistance to the 3 rusts, although stripe rust resistance (primarily adult plant type) is not as high as that of Edwall and Penawawa(Table 1). Yielding ability of WA7183 is equal to that of Edwall and Penawawa, and it shows good lodging resistance. WA7183 has satisfactory quality properties. WA7183 is proposed largely for use in conservation tillage management situations where hessian fly damage can be serious The proposed name is Wakanz, to reflect its origin through coop-

erative efforts of Washington, Kansas and New Zealand scientists. WA7183 is a direct result of the accelerated "shuttle" breeding program which has employed 4 off season (winter period) increases in New Zealand.

2. WA7075 (Spillman) - is a high protein semidwarf hard red spring wheat, now in pre-breeder seed production. It is the first development in the WSU program to increase protein production capacity combined with yielding capacity equal to McKay and Wampum of HRS wheats. WA7075 has satisfactory quality properties and the grain averages about ½ percentage point higher protein than McKay and Wampum, and an outstanding combination of resistances to mildew and to stripe, leaf, and stem rusts. Its stem rust resistance is superior to that of Wampum and its base of resistances appears different from that of McKay, Wampum and other wheats currently in production. Its lodging resistance is excellent, but probably can be lodged under irrigation and high N fertility conditions. Breeder seed stock was produced in Arizona and will be available for 1987 Foundation seed production. The name Spillman was selected in recognition of WSU wheat breeder Geneticist W. J. Spillman who was a rediscoverer of the laws of genetics who conducted genetic work at WSU in its early days in appropriate recognition of WSU's Centennial.

3. WA7187 (Wadual)- This semidwarf soft white spring wheat offers a new development in soft wheat processing quality aimed at capturing specialty flour and other new markets, including potential overseas markets. The processing of quality properties of these lines combines the essential features of both pastry and bread type wheats into a single genotype and variety. Laboratory tests have shown these wheats will produce cookies, noodles, sponge cakes and flat breads similar or superior to those of current soft white wheats when using formulae appropriate for these products and when using a bread formula, can produce breads comparable to typical hard red spring wheats. Their water absorption properties are on the low end for hard wheats and in the high range for soft wheats. Their main distinction from typical soft wheats is in their dough mixing properties which are similar to typical bread wheats. These wheats carry moderate resistances to stripe and leaf rusts and high resistance to stem rust, but are susceptible to mildew and the hessian fly much as are most other SWS wheats. (Table 1)

Yield performance data indicate that these lines yield comparably with current SWS and HRS wheats.

Advances in On-going Research

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

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

With the introduction and evident potential of the dual quality wheats, an increasing emphasis will need to be placed on the incorporation of individual quality traits in a new cycle of breeding for disease and pest resistance and improved yield. The advances made in that area are in large measure due to the dedicated and extensive efforts also by Mr. Gordon Rubenthaler, leader, USDA Western Wheat Quality Laboratory, Pullman.

Shuttle Breeding

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

Soft White Spring Wheats

The initial phases of the "shuttle breeding" program already have been influential on progress toward the release of SWS wheats, Edwall and Penawawa (Tables 1,2,3), and have been especially effective toward the incorporation of a hessian fly resistance base in the breeding populations of the WSU spring wheat program. This project has benefited considerably from the cooperation and input of Drs. J. Hatchett, USDA Manhattan, Kansas and Keith Pike, WSU, Prosser, Washington. An SWS selection (WA7183 named Wakanz) from the early phase of this hessian fly resistance breeding program is now in the foundation seed increase and release channels toward its early availability to aid in conservation tillage management. New crosses among soft white wheats involve the introduction of resistances to the hessian fly as a standard, although we are yet concentrating on use of the H_3 resistance gene. Dr. Keith Pike, WSU entomologist, Prosser, already has begun screening segregating materials for hessian fly resistance, providing for the accelerated development of resistant lines. As this screening program develops, other hessian fly resistance genes will be included in the program.

Hard Red Spring Wheats

Considerable progress already has been made also toward the development of hessian fly resistant HRS wheats. Besides building the hessian fly resistance germplasm into breeding populations, we have isolated several high performing, good quality disease resistant lines from a genetics research cooperation program involving Japanese scientists. This cooperative effort also used the New Zealand increase program, and is the means by which the initial phase of the "shuttle breeding" program was achieved. We were fortunate that one of the parent lines selected for the genetics research also carried hessian fly resistance. The most advanced lines from these studies are included in Tri State Regional Spring Wheat Nurseries. Several lines now are in wide testing. Progress also has been made toward enhancing the protein production capacity of our HRS wheats. Spillman (Tables 1, 3, 4) represents a first stage development in efforts to improve grains protein capacity in HRS wheats.

Commercial Variety Trial

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

WSU's hessian fly resistant Wakanz is in Foundation Seed production. Hessian fly resistance will be essential when spring wheats are grown extensively under no- or mini-till management systems, or near winter wheats so managed. Of the publicly developed SWS varieties, Edwall will likely be the most commonly grown in 1985, as ample seed supplies are available, and its disease resistance remains adequate. It will gradually be replaced by Edwall, which carries higher resistances to stripe rust, leaf rust and stem rust and has a better yield performance record. All other privately developed entries are hard red spring types; developed largely for the northern Great Plains region. Entries included come from CENEX, Agripro, Great Plains Seeds, Firstline Seeds, and Western Plant Breeders.

Among the HRS wheats, McKay (ID) appears to be the current best performer next to Wampum. Wampum maintains its stripe and leaf rust resistance, but is highly susceptible to stem rust. McKay is resistant to local forms of all rusts. The new 1987 release Spillman should replace most of the Wampum when certified seed is available. Other entries have not been evaluated sufficiently for comment.(see table 3)

Locations and Management of Evaluation Trials

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

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

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

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

Table 1 Maturity, Disease, Pest Reactions SWS Wheats

	Stripe Rust	Leaf Rust	Stem Rust	Mildew	Hessian Fly	Rel.Heading Date
Waverly	MR	RMR	MR	S	S	+1
Edwall	RMR	RMR	R	MS	S	0
Dirkwin	R	R	R	S	S	+1
Owens	R	R	R	S	S	+1
Penawawa	RMR	RMR	R	MS	S	+1
Wakanz	RMR	RMR	R	S	R	+1
Wadual	MR	MR	R	SS	S	-1
Treasure(ID)	R	S	R	MS	S	+1

Table 2 1986 State White Spring Wheat Trial #52

	Yield						Pullman		
Location:	Pullman	Pullman (Annual)	Harring-ton	Waitsburg	Davenport	Royal Slope	Test Wt. (Lb/Bu)	Plant Ht. (In.)	Head. Date (June)
	(Bu/Ac)								
Variety:									
Fielder	64	47	30	51	38	105	60.4	28	17
Dirkwin	73	50	28	54	45	98	57.1	28	18
Owens	71	61	30	50	38	114	62.0	29	16
Waverly	63	43	29	49	36	105	58.4	28	18
Edwall	67	53	29	53	43	98	58.6	27	16
Penawawa	69	45	26	51	38	112	61.0	25	17
WA007176	62	51	26	48	44	114	60.3	28	18
Wakanz	73	53	29	53	40	107	61.0	27	18
Wadual	67	50	26	46	40	102	61.6	29	16
WA007188	66	53	28	45	40	97	60.3	28	18
WA007492	73	55	30	51	39	114	60.5	28	19
PI468960	70	55	29	55	45	107	58.6	27	17
ID000315	76	55	28	53	46	114	59.9	28	16
WA007496	83	52	29	54	47	104	58.8	25	15
WA007497	74	52	26	48	39	99	61.1	28	16
LSD .05*	8	5	4	5	7	8			

*LEAST SIGNIFICANT DIFFERENCE: The difference in yield between any two varieties grown in the same nursery are not significant unless the difference exceeds the LSD value.

Previous Crop Data: Pullman (Spillman Farm):Peas
Pullman (Quist Farms): Spring Barley
Harrington (Bob Kramer): Winter Wheat
Waitsburg (Foundation Farms): Spring Wheat
Davenport (Wilke Farm): Winter Wheat
Royal Slope Exp. Station, Irrig.: Fallow

Table 3 1986 Commercial Spring Wheat Trial #46

	Yield				Pullman		
Location:	Pullman	Lind (Bu/Ac)	Walla Walla	Royal Slope	Test Weight (Lb/Bu)	Plant Height (In)	Heading Date (June)
Variety:							
(Soft White)							
Fielder	71	27	93	108	62.5	27	16
Urquie	81	25	88	99	58.7	29	21
Dirkwin	74	23	80	100	60.2	28	18
Owens	71	28	91	110	63.6	29	15
Waverly	67	26	94	97	62.7	27	18
Landmark	69	22	62	95	64.0	28	16
Edwall	74	27	85	105	61.3	28	15
PI468960	72	26	88	105	61.0	28	17
Bliss	74	27	90	100	61.1	28	18
WA006916	74	27	101	114	63.4	27	13
Penawawa	70	26	97	109	62.1	30	16
Wakanz	78	28	90	109	63.6	28	17
WA007186	75	25	79	92	63.6	27	13
Wadual	70	26	89	107	63.6	30	16
WA007188	77	25	88	93	62.7	29	17
Treasure	64	28	--	113	61.3	27	18
(Hard Red)							
Yecora Rojo	57	25	80	93	63.5	20	11
Wampum	68	28	89	110	63.3	34	17
McKay	81	28	93	108	60.0	28	17
Buck Mapuche	59	24	74	91	63.9	28	11
Bronze Chief	52	25	79	85	61.5	23	11
Kodiak	67	24	93	94	59.8	16	12
Nordic	74	26	81	104	63.7	30	16
Telemark	64	26	88	96	63.0	26	14
Ceres	68	23	84	99	62.9	29	16
John Britt #9	57	24	76	96	64.7	30	14
NK 751	66	26	89	103	63.4	25	12
Spillman	70	26	96	102	61.9	28	16
WA007326	68	26	83	101	62.6	29	17
WPB00906	69	25	83	93	62.8	28	12
WRC08008	59	22	85	92	62.5	27	12
Copper	55	21	--	106	62.4	27	14
LSD .05*	8	3	10	8			

Previous Crop Data:

Pullman (Spillman Farm): Peas
Lind Dry Land Exp. Station: Fallow
Walla Walla (Foundation Farms, Irrig.): Peas
Royal Slope Exp. Station, Irrig.: Fallow

Table 4 1986 Hard Red Spring Wheat Trial #47

	Yield						Pullman		
Location:	Pullman	Connell	Harrington (Bu/Ac)	Waitsburg	Davenport	Royal Slope	Test Wt. (Lb/Bu)	Plant Ht. (In)	Head. Date (June)
Variety:									
Wampum	67	31	28	52	38	90	62.8	31	16
McKay	63	30	30	56	37	90	62.3	27	16
NK 751	60	31	25	51	40	86	62.5	24	14
WPB 906R	59	25	24	49	38	88	62.6	27	13
Spillman	66	30	31	52	41	90	62.0	27	16
WA007190	65	28	30	48	38	93	61.9	27	17
WA007326	68	27	29	51	42	83	63.2	29	18
ID007330	54	26	25	44	34	90	61.7	29	16
ID000308	63	31	27	47	41	90	63.8	29	18
Nordic	67	30	27	59	37	93	63.9	29	18
WA007495	60	29	22	49	38	97	62.3	27	16
HP830013	58	30	24	49	33	95	61.5	26	17
WA007493	61	29	28	51	40	93	62.7	25	13
WA007494	67	29	27	51	46	93	63.4	25	13
LSD .05*	8	3	3	4	8	12			

Previous Crop Date:

Pullman (Spillman Farm): Peas
Connell (Bauermeister Farms): Fallow
Harrington (Bob Kramer): Winter Wheat
Waitsburg (Foundation Farms): Spring Wheat
Davenport (Wilke Farm): Winter Wheat
Royal Slope Exp. Station, Irrig.: Fallow

SOFT WHITE WINTER WHEAT IMPROVEMENT

C. J. Peterson, Jr., R. E. Allan, K. J. Morrison, G. L. Rubenthaler, J. A. Pritchett, P. E. Reisenauer, D. F. Moser and K. Hinnekamp

Washington wheat growers harvested 120.7 million bushels of wheat in 1986 for an average yield per acre of 49.8 bushels. Production was 6 percent lower than in 1985 because fewer acres were harvested. November and December were very cold. Snow arrived early and stayed for a long period. Consequently snow mold and dwarf bunt caused some yield reduction. June was quite warm during flowering and seed development and this also reduced production in some areas.

New Varieties

Dusty, a semidwarf soft white winter wheat, has a common type head with white chaff. Dusty matures 2 to 3 days later than Daws. The straw strength of Dusty is weaker than that of Daws and Stephens, and it may lodge under high production. It is equal to Lewjain and Hill 81 in winter hardiness. Dusty is resistant to common bunt and has adult resistance to stripe rust. It is susceptible to flag smut, leaf rust, and *Cephalosporium* stripe. Dusty is quite susceptible to *Cercosporella* foot rot and to stem rust. The bushel weight of Dusty is slightly lower than that of Daws and Lewjain and under heat and/or water stress it may be considerably lower. Dusty was developed by USDA-ARS and WSU.

Promising Lines

Two lines (WA007163 and WA007166) are being increased for possible release in 1988. Both lines are resistant to *Cercosporella* foot rot, stripe rust, leaf rust, and stem rust. In the absence of disease they have generally equalled or exceeded the current commercial cultivars. WA007163 is a common semidwarf soft white winter wheat. WA007166 is a semidwarf soft white winter club wheat.

1985/86 Nurseries

The 1985/86 WSU-USDA/ARS soft white winter wheat nursery was grown at Pullman (early and late), Pomeroy, Walla Walla, Ritzville, and Cunningham, Washington. Lewjain (87.8 bu/a) was the best commercial cultivar when the grain yields were averaged across all locations and Daws (85.8 bu/a) was second. Tres was the best commercial club wheat.

The Pullman Early nursery was sown September 6, 1985. One half of each plot was inoculated with *Cercosporella* foot rot fungus in the fall and the other half was sprayed with a fungicide early in the spring to control the disease. Foot rot infection was light and yields were generally reduced approximately 11 percent. Grain production was also reduced in both treatments by the *Cephalosporium* stripe. Lewjain (92.2 and 101.0 bu/a) was the highest yielding commercial cultivar under both treatments.

The Pullman Late nursery was sown October 3, 1985. The entire nursery was fertilized before planting (60# nitrogen/a) and then one half of each plot received an additional 60# in the spring. Lewjain (91.5 and 84.4 bu/a) produced the most grain of the commercial cultivars under both treatments.

The Pomeroy nursery was sown September 24, 1985. Dusty (76.6 bu/a) was the highest yielding commercial cultivar. Tres, Stephens, Daws, Lewjain, and Hill 81 produced 75.3, 68.6, 73.3, 72.1, and 64.2 bushels of grain per acre, respectively.

The Walla Walla nursery was sown October 15, 1985. Tres (94.3 bu/a) a club wheat, was the highest yielding commercial cultivar. Stephens, Daws, Lewjain, Hill 81, and Dusty produced 86.3, 84.1, 84.9, 85.3, and 92.2 bushels of grain per acres, respectively.

The Ritzville nursery was sown October 15, 1985. Daws (55.4 bu/a) was the highest yielding commercial cultivar. Tres, Stephens, Lewjain, Hill 81, and Dusty produced 53.8, 41.5, 54.4, 43.7, and 48.7 bushels of grain per acre, respectively.

The irrigated nursery at Cunningham was planted September 20, 1985. Crew (122 bu/a), a club wheat, was the highest yielding commercial cultivar. Stephens, Daws, Lewjain, Hill 81, and Dusty produced 105.4, 121.6, 113.2, 118.1, and 109.8 bushels of grain per acre, respectively. Dusty has performed very well in four of the past 6 years. Lodging and stem rust reduced the grain production in Dusty in the two poor years.

Table 1 shows the average yields (bu/a) for 11 winter wheat varieties grown for the past three years at five locations in Washington. Lewjain has the best overall yield and produced the most grain at Ritzville and Cunningham. Three varieties (Dusty, WA007163 and WA007166) produce about the same amount of grain over all locations as Lewjain.

Table 1. Average yield data (bu/a) on 11 winter wheat varieties grown for three years at five locations in Washington.

	Pullman	Pomeroy	Walla Walla	Ritzville	Cunningham	Average
Daws	65	60	88	59	114	77
Stephens	65	48	92	37	94	67
Dusty	79	62	102*	53	105	80
Lewjain	73	61	92	61*	117*	81*
Hill 81	71	58	90	51	104	75
Malcolm	67	59	90	44	112	74
WA007163	82*	63*	94	55	105	80
Oveson	75	55	94	34	100	72
Crew	72	60	88	57	106	77
Tres	71	57	92	58	105	77
WA007166	76	62	98	58	104	80

HARD RED WINTER WHEAT BREEDING AND TESTING

E. Donaldson and M. Nagamitsu

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

Andrews is a semidwarf hard red winter wheat with good snowmold tolerance and fair TCK resistance. Andrews has an excellent yield record in the Waterville nursery whether snowmold was present or absent. Overall quality is satisfactory. A tendency toward weak straw and a susceptibility to stripe rust appear to be its major weaknesses. Foundation seed of Andrews should be available this fall.

Four new hard red winter wheat selections were entered into the Western Regional Hard Red Winter Wheat nursery. Preliminary testing indicates that they have good yield capabilities with satisfactory quality and disease resistance. Two selections showed superior emerging ability and two selections usually show above average whole grain protein.

The 1986 performance of 5 hard red winter wheats, compared to Wanser and Kharkof, are given in the following tables. In an average of the dryland nurseries at Lind, Horse Heaven, Finley, and Connell, the highest yielding varieties were Winridge and Weston with 23 bushels per acre each. Hatton averaged 22 bushels per acre. Andrews had extensive mouse damage in each plot in the Finley nursery and averaged only 17 bushels per acre, overall. In a five year average of these nurseries Batum yielded 35 bushels per acre. Hatton, Winridge and Weston yielded 34, 32, and 32 bushels per acre, respectively. Andrews has not been grown in all locations for 5 years. Percent whole grain protein content was high in 1986. Average percent whole grain protein contents were 14.6, 14.4, 13.9, 13.6, and 12.6 for Weston, Batum, Andrews, Winridge, and Hatton, respectively. Four year average whole grain protein contents were 13.3, 13.1, 12.4, 12.2, and 11.7 percent for Andrews, Weston, Batum, Hatton, and Winridge, respectively.

Table 1. Summary of agronomic characteristics of winter wheat varieties grown at Finley in rod row nurseries, 1984-86.

Variety	1986 Yield bu/a	Yield % Kharkof	Av. Test Wt.	No. years grown
Wanser	10.7	97	62.7	3
Hatton	17.3	131	63.9	3
Batum	15.4	104	61.7	3
Weston	18.0	112	63.2	3
Winridge	14.0	100	61.8	3
Andrews	8.0	83	61.6	3
Kharkof	15.6	100	62.3	3

Table 2. Summary of agronomic characteristics of winter wheat varieties grown at Horse Heaven Hills in rod row nurseries, 1951-86.

Variety	1986 Yield bu/a	Yield % Kharkof	Av. Test Wt.	No. years grown
Wanser	19.9	114	62.2	3
Hatton	17.6	116	63.6	3
Batum	18.8	112	60.2	3
Weston	18.9	110	62.9	3
Winridge	23.9	121	60.6	3
Andrews	18.7	117	60.9	3
Kharkof	20.4	100	62.1	3

Table 3. Summary of agronomic characteristics of winter wheat varieties grown at Connell in rod row nurseries, 1975-86.

Variety	Av. Test Wt.	1986 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. years grown
Daws	60.8	*	39.6	128	8
Lewjain	61.5	27.7	41.1	131	4
John	61.5	26.1	40.4	129	4
Stephens	60.0	19.1	38.0	126	9
Tres	62.2	*	51.8	123	2
Wanser	62.7	27.1	34.9	112	10
Hatton	63.6	27.9	39.0	130	9
Weston	63.3	30.9	39.1	129	7
Winridge	61.6	28.7	39.4	125	4
Batum	61.1	27.3	40.6	129	4
Andrews	61.3	22.1	41.0	130	5
Kharkof	61.8	22.4	31.0	100	10

*Not grown 1986

Table 4. Summary of agronomic characteristics of winter wheat varieties grown near Harrington in rod row nurseries, 1952-86

Variety	Av. Test Wt.	1986 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. years grown
Nugaines	61.5	36.1	42.3	135	21
Daws	60.0	*	46.5	143	12
Dusty	58.7	36.6	47.5	140	4
Lewjain	60.4	36.2	48.8	151	10
John	59.4	32.0	44.3	138	6
Stephens	59.4	37.3	45.6	139	13
Hill 81	59.5	30.4	48.4	141	5
Moro	58.9	34.4	42.3	136	21
Crew	58.9	33.7	52.7	156	9
Tyee	58.4	38.7	51.6	158	11
Tres	59.6	35.4	51.9	155	7
Batum	58.9	36.4	51.1	149	5
Hatton	63.0	35.5	47.2	145	11
Kharkof	61.0	35.8	33.9	100	33

*Not grown in 1986

Table 5. Summary of agronomic characteristics of winter wheat varieties grown near Waterville in rod row nurseries, 1952-86.

Variety	Av. Test Wt.	1986 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. years grown
Stephens	59.4	34.3	38.3	132	7
Lewjain	61.7	30.6	47.6	167	5
Sprague	61.0	34.5	45.8	147	10
John	61.7	26.1	45.3	159	5
Crew	60.4	30.3	38.0	127	4
Tyee	59.2	26.4	40.3	145	6
Tres	61.3	33.3	30.2	104	2
Wanser	58.6	25.0	35.7	111	18
Hatton	63.8	24.5	34.8	131	8
Weston	62.3	28.9	34.4	118	7
Winridge	60.8	31.7	36.0	130	6
Batum	60.3	36.1	36.9	133	6
Andrews	60.7	31.4	41.6	146	5
Kharkof	61.1	26.7	32.2	100	27

Table 6. Summary of agronomic characteristics of winter wheat varieties grown at Lind in rod row nurseries, 1952-86.

Variety	Av. Plant ht.	Av. Test wt.	1986 Yield bu/a	Av. Yield bu/a	Yield % Kharkof	No. of years grown
Nugaines	26	61.3	21.4	35.3	126	22
Daws	29	59.2	*	34.1	130	12
Dusty	24	60.2	26.1	28.5	150	4
Lewjain	26	59.4	20.9	31.6	129	10
John	26	60.0	20.4	31.2	122	6
Stephens	26	58.2	12.6	30.6	121	14
Hill 81	26	59.2	15.8	27.0	105	5
Moro	30	58.5	16.3	34.6	121	23
Crew	26	58.2	19.1	33.5	135	9
Tyee	26	58.5	13.6	31.2	116	11
Tres	26	60.0	9.0	33.2	127	7
Wanser	31	61.5	27.4	32.8	115	23
Hatton	30	62.5	24.8	31.8	129	11
Weston	33	61.5	23.4	31.4	126	9
Winridge	30	60.8	27.1	32.8	126	7
Batum	27	60.4	28.7	36.3	142	6
Andrews	27	60.7	20.2	30.3	116	5
Kharkof	33	60.6	22.8	28.5	100	32

*Not grown 1986

RECENT ADVANCES IN WINTER WHEAT GENETIC STUDIES

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

Resistance to Strawbreaker Foot Rot

Common soft white winter, WA 7163 and club WA 7166 received preliminary approval for release and breeder seed is on increase. Their resistance to strawbreaker foot rot has been consistent. In 6 years of trials, WA 7163 and WA 7166 exhibited mean foot rot-induced yield losses of 7 and 1% compared to losses of 17 to 33% for Tyee, Stephens, Daws, and Nugaines. Mean yields of foot rot inoculated trials for WA 7163, WA 7166, Tyee, Daws, Stephens and Nugaines were 114, 97, 79, 77, 76 and 68 bu/ac, respectively. When averaged across 40 Washington State trials where foot rot was not a factor, WA 7163 and WA 7166 have yielded competitively with many varieties. Mean yields were: WA 7163 (83 bu/ac), WA 7166 (79 bu/ac), Nugaines (76 bu/ac), Daws (82 bu/ac), Stephens (74 bu/ac), Lewjain (87 bu/ac), Crew (80 bu/ac), and Tres (79 bu/ac).

The inheritance of resistance to strawbreaker foot rot was studied in a cross between VPM/Moisson 421 (resistant) and Sel. 101 (susceptible). Based on foot rot lesion index ratings, heritability for foot rot reaction was high (61 to 83). Selection based on lesion index could begin in the F_3. The lesion index segregation patterns among F_2 derived progeny of this cross suggested two genes controlled reaction. A strong dominant gene probably comes from VPM. Another gene with weaker resistance probably comes from Moisson. Lodging correlated highly with lesion index and could be used to select for foot rot resistance. Results of D. E. Roberts demonstrated correlation between foot rot lesion indices and yield losses induced by foot rot. The r values were not large, however. Her data suggested that low yield loss in wheat may be due to either tolerance or resistance, or a combination of both.

The Effects of Different Semidwarf Genes on Wheat Emergence

Two years of tests confirm that the Rht_1 semidwarf gene of wheat has a less deleterious effect on wheat stand establishment than the Rht_2 gene. When rate of emergence (ERI) and percent stands (PS were compared between isolines of five genetic backgrounds in our 1985 and 1986 tests, Rht_2 and Rht_1 isolines had lower ERI or PS values than their nonsemidwarf counterparts in 85 and 40% of the comparisons, respectively. The mean ERI values across backgrounds and tests for nonsemidwarf (rht_1, rht_2), Rht_1 semidwarf (Rht_1, rht_2), Rht_2 semidwarf (rht_1, Rht_2), and dwarf (Rht_1, Rht_2) isolines were 347, 272, 218 and 161, respectively; for PS the respective values for these isolines were 66, 61, 54 and 45. These results support use of the Rht_1 gene rather than the Rht_2 gene in breeding semidwarf wheats for areas where emergence is a problem.

Genotype by Environment Study of Soft White Winter Wheat Quality

A genotype by environment study of six quality criteria was completed by L. M. Bassett involving the soft white winter cultivars, Daws, Nugaines, Stephens, and Lewjain. The study comprised 21 locations in 1983, 1984 and 1985, and included evaluations of flour yield, protein content, alkaline water retention capacity, NIR kernel hardness, sedimentation score, and cookie diameter. Although all four cultivars are regarded to have acceptable soft wheat quality, Lewjain and Stephens proved to be superior to Daws and Nugaines. Daws had significantly harder kernels, higher AWRC and smaller cookie diameter than all other cultivars. Stephens had significantly higher protein content but lower AWRC and sedimentation than the other three cultivars. Although Stephens had the lowest mean grain volume weight, it achieved the highest mean flour yield. Lewjain had the largest cookie diameter, sedimentation score, and softest kernel texture. When all quality traits were considered, Lewjain and Stephens expressed the greatest and the least stability across all trials, respectively. Cluster analysis identified three locations that were the most representative of the 21 locations for the main quality traits. The best locations upon which to base quality tests were Walla Walla, Mayview and Uniontown.

Developing Genetic Stocks with Different Photoperiod Response

E. Haro has been assigned to the development and evaluation of near-isogenic lines differing for photoperiod response. The 5th and 6th backcrosses were made in transferring photoperiod response genes (*Ppd*) from Early Blackhull and Extra Early Blackhull to Nugaines and Paha. The 4th backcrosses were achieved in transferring *Ppd* genes from two Oriental sources to Daws, Brevor, Luke, Barbee, Nugaines, Paha and Wanser. Replicated trials were sown at Pullman and Walla Walla to evaluate yield and other agronomic trials of about 50 lines each of populations involving the Blackhulls, Paha and Nugaines.

Breeding Wheats Adapted to Conservation Tillage Management

Tests conducted during 1978-1985 to assess adaptive properties of genetically diverse wheat lines and populations to no-till and till management were summarized. Based on 29 location years, mean no-till yields averaged 97% of the mean yields under conventional tillage practices. Tillage practice affected yield in about 60% of all analyses and among these no-till significantly reduced yield about 65% of the time. Significant genotype X tillage practice interactions occurred for yield and 15 other traits for 10% of the analyses. Yield rankings of the cultivars were similar under no-till and till culture. Positive correlations occurred between the two tillage values of 0.67 to 0.74. Test with wheat isolines indicated complex interactions between semidwarf (Rht_1, Rht_2) genes and no-till yield performance. Different combinations of Rht_1 and Rht_2 genes interacted with genetic background to affect no-till yield performance. Genes affecting awn development and heading date were neutral, whereas the club spike gene enhanced no-till yield performance. Significant genetic advance could be made for no-till winter wheat yield performance based on till yield performance.

Response of Genetically Diverse Winter Wheat Populations to No-Till vs. Till Management

K. K. Hwu compared the environmental differences as measured by selection response of 18 genetically diverse populations between sub-populations continuously grown under no-till and till culture. Each population was genetically diverse for one or more agronomic traits. The 18 populations had been planted under till and no-till culture for 5 consecutive years and were derived from seed produced from the previous year. Natural selection affected most of the populations and favored genotypes with increased heading date, plant height, tiller number, biological and grain yield, under no-till regardless of the previous management. Grain volume weight and seed weight consistently decreased over years. Since populations did not respond to previous cultural treatment, differential selection did not occur. Apparently no-till and till culture have similar effects on genotypic population structure.

BARLEY BREEDING AND TESTING IN WASHINGTON

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

Production

Barley production in 1986 in Washington was approximately 1.1 million tons (45 million bushels) from 900,000 acres. The state average yield was about 1.2 tons/acre (50 bushels/acre). Washington was the fifth largest barley producing state in the U.S. The top four barley varieties grown in 1986 were WSU releases. In rank order, they were Steptoe, Boyer, Kamiak and Advance. The planting projection for Washington for 1987 indicates that there will be over 660,000 acres of barley.

Objectives

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

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

An additional objective is to measure variety response to various cultural practices. For the second year the effects of tillage methods and nitrogen levels are being investigated at Pullman. (See W. L. Pan article) Annual cropping system effects are being studied at Davenport (Wilke Res. & Ext. Farm), Harrington, Connell, Waitsburg and Pullman.

Results

The newer varieties developed at W. S. U. are described in front of the brochure under recommended barley varieties for the state of Washington. Yield results are summarized in the tables below along with newer high yielding selections and other commercial cultivars.

Winter Barley

Winter barley survival was variable at the Davenport Mielke nursery indicating a good test for winterhardiness. This was in contrast to the Pullman trials where survival was nearly 100%. Winter barley agronomic data is presented in Table 1. A decline in yield potential has been indicated for Showin the past few years compared with the standard commercial varieties. This represents a reversal in performance indicated at the time of release of Showin. However, because of the short stature and lodging resistance, its potential for irrigated production is being evaluated at Othello and Prosser this year. Newer advanced breeding lines with high yield potential are also presented in Table 1.

Winter sown spring barley varieties survived differentially this past winter. Steptoe survived nearly 100% while Andre and Advance killed out nearly 100%. Cougbar was intermediate in survival.

Spring Barley

Spring barley performance is presented in Tables 2-6. Although Steptoe continues to be a high yielder, WSU's newest 2-row and 6-row releases, Andre and Cougbar, respectively, have performed well at many locations (Tables 2,4,5). Several advanced breeding lines have performed quite well especially the 2-row WA 8771-78. Commercial or proprietory varieties, all feed types, are compared in Table 3. The performance of selected varieties and lines in the annual cropping (planting on recrop ground) experiment are presented in Table 4. Extension nursery data is presented in Table 5. Spring barley performance of selected varieties and lines at Lind are presented in Table 6. WA8771-78 again performed well here indicating adaptation to a broad range of conditions.

Table 1. Six-row winter barley state nurseries.

Variety	Yield Averages: 1986 Pull-man	Pom-eroy	Walla Walla	Average	2 yrs Pull-man	4 yrs Pull-man	Pullman 4 yrs: Test wt.	Plump-thin	Plant ht.
	T/a						-lb/a-	-%-	-in-
2554-81	2.3	-	-	-	2.4	2.8	51	48-16	35
2531-81	2.2	1.9	2.6	2.2	2.4	2.8	51	41-18	36
1869-80	2.2	2.2	2.4	2.3	2.4	2.6	52	69-9	34
Kamiak	1.9	1.6	2.3	1.9	2.3	2.4	51	65-14	41
Boyer	1.8	2.0	2.9	2.2	2.1	2.5	49	71-11	35
1574-77	1.8	2.1	2.3	2.1	2.3	2.7	49	65-10	33
Hesk	1.7	2.0	2.9	2.2	2.3	2.7	49	67-11	35
Showin	1.5	1.7	2.4	1.9	2.0	2.2	48	49-22	28
Scio	1.5	1.9	2.7	2.0	2.1	2.5	49	72-8	34

Table 2. Spring barley state nurseries, 5 locations.

Variety	Row type	Yield Averages: 1986 Pull-man	Pom-eroy	Day-ton	Walla Walla	Royal Slope*	Avg.	5 yr Pull-man	1985 & 86 Avg. Pullman: Yield	Test wt.	Plump-thin	Plt ht.
		T/a								-lb/bu-	-%-	-in-
Steptoe	6	2.1	1.2	1.0	1.9	3.2	1.9	2.1	2.0	48	85-6	30
8771-78	2	1.9	1.2	1.0	1.6	3.0	1.8	2.2	2.7	53	90-3	30
12809-83	6	1.9	1.3	0.7	1.5	2.8	1.6	-	2.1	50	70-10	32
9776-81	2	1.8	1.2	1.1	1.4	2.9	1.7	-	2.0	51	72-9	28
9448-83	2	1.8	1.6	1.0	1.9	3.1	1.9	-	2.0	50	83-5	29
Clark	2	1.8	1.4	1.0	1.5	2.8	1.7	2.0	2.0	51	85-3	31
Cougbar	6	1.7	1.1	0.7	1.7	3.2	1.7	2.1	1.9	50	63-10	30
8707-80	6	1.7	0.9	0.7	1.6	3.2	1.6	2.0	1.8	48	86-4	32
Andre	2	1.7	1.4	1.1	1.6	2.9	1.7	2.0	2.0	52	68-9	29
Klages	2	1.7	1.2	0.9	1.5	2.9	1.6	1.8	1.8	51	71-8	30
Morex	6	1.6	0.9	0.9	1.3	2.6	1.4	1.7	1.8	51	82-5	36
Advance	6	1.4	0.9	0.9	1.9	2.8	1.6	1.9	1.7	48	61-17	28

*irrigated

Table 3. Spring barley commercial nursery, 2 locations, 1986.

	Yield			Pullman			
Variety	Pull-man	Royal slope*	Average	Test wt.	Plump-thin	Plant ht.	Royal Slope Lodging
Steptoe	2.0	3.2	2.6	50	97-1	30	31
Lindy	2.0	3.3	2.6	52	99-0	30	54
Lud	1.9	3.1	2.5	53	90-2	29	12
Menuet	1.9	2.9	2.4	54	93-1	28	16
WA7773-83	1.8	3.0	2.4	54	96-1	30	11
Apex	1.8	2.8	2.3	54	94-2	28	9
Piston	1.8	2.7	2.2	53	85-4	29	38
Efron	1.8	3.0	2.4	52	88-2	29	8
Bellona	1.7	3.2	2.4	53	97-1	30	7
Spirit	1.6	3.0	2.3	54	94-2	31	6
Columbia	1.6	3.2	2.5	49	95-1	24	4
Kombar	1.6	3.0	2.3	47	90-2	27	0
Gus	1.5	2.5	2.0	51	90-3	24	28

* Irrigated

Table 4. Spring barley performance - 5 dryland annual cropping locations, 1985 & 1986.

					1986 Yield					Yield Averages		
Cultivar/ line	Row type	Plant ht.	Test wt.	Plump-thin	Pull-man	Walla Walla	Daven-port	Con-nell	Har-rington	1986	1985	85&86
		-in-	-lb/bu-	-%-	t/a							
Cougbar	6	24	51	78-5	2.5	1.4	0.9	1.0	0.7	1.4	1.5	1.4
Steptoe	6	24	49	92-2	2.5	1.8	1.1	1.0	0.6	1.4	1.4	1.4
Lewis	2	25	54	91-3	2.4	1.6	1.1	0.8	0.8	1.3	1.5	1.4
9776-81	2	24	53	81-4	2.3	1.9	1.0	0.9	0.9	1.4	1.4	1.4
Clark	2	26	52	84-5	2.2	1.4	1.3	1.0	0.8	1.4	1.4	1.4
Andre	2	25	53	69-10	2.2	1.6	0.9	0.9	1.0	1.3	1.3	1.3
8771-78	2	24	53	88-4	2.2	1.6	1.1	0.9	0.9	1.4	1.5	1.4
Advance	6	20	49	75-9	2.2	1.4	0.8	1.0	0.5	1.2	1.4	1.3
Gus	6	21	49	84-4	2.0	1.3	1.2	0.6	0.5	1.1	1.2	1.2
Kombar	6	22	46	83-4	1.8	1.3	0.7	0.7	0.4	1.0	1.0	1.0

* Pullman, Walla Walla, Davenport, Harrington, Connell

Table 5. Spring barley extension nurseries 3 year (1984-86) yield averages (tons/acre).

Variety	Union-town	May-view	Farm-ington	Fair-field	St. John	Dusty	Deep Creek	Rear-dan	La-mont
Steptoe	2.1	2.1	1.7	1.8	1.5	1.5	2.2	1.4	1.2
Cougbar	2.0	1.8	1.7	1.6	1.8	1.2	1.9	1.2	1.2
Advance	1.9	1.9	2.0	1.7	1.5	1.3	2.0	1.4	1.3
8771-78	1.9	2.0	1.6	1.8	1.6	1.3	1.9	1.4	1.2
Andre	1.7	1.9	1.5	1.5	1.5	1.0	1.8	1.2	1.1

Variety	Asotin	Wilbur	Goldendale	Bickleton	Average 39 Loc yrs	Average 12 Loc 1986
Steptoe	1.4	1.4	1.5	0.7	1.6	1.4
Cougbar	1.0	1.3	1.3	0.6	1.4	1.4
Advance	1.2	1.5	1.4	0.6	1.5	1.4
8771-78	1.1	1.4	1.4	0.7	1.5	1.5
Andre	1.0	1.2	1.1	0.6	1.3	1.3

Table 6. Lind Spring Barley Averages

3 yr. Av. (1984-86)	Plant ht.	Lod	Plump seed	Test wt.	Yield
	-in-	-%-	-%-	-lb/bu-	-lb/a-
Klages x (8537-68)2, 8771-78	19	0	72	50	2000
Steptoe	21	0	81	48	2000
Klages2 x 8537-68, 8908-78	20	0	75	50	2000
Lindy	20	0	79	48	1900
11309-73 x 9933-75, 8359-80	21	0	75	48	1900
Clark	19	0	63	51	1900
Andre	20	0	34	47	1800
Piston	19	0	59	51	1800
Cougbar	20	0	55	49	1700
Advance	21	0	54	47	1400

TRITICALE

C. J. Peterson Jr.

Triticale is a cereal that was developed by crossing rye and wheat. Plant breeders hope to combine the good traits of both cereals into a superior grain. Early triticale had many undesirable characteristics such as: low yield, shriveled grain, poor seed set, and excessive plant height. Plant breeders have made considerable progress in improving triticale in the last 10 years.

Triticale yields are now quite competitive with the locally adapted winter and spring wheats. When the grain yields from the fall sown triticales were averaged over a six year period (1981 to 1986) (Table 1), the triticale, Whitman, (a spring triticale) averaged 18 percent more grain than Stephens and Daws. Three of the four triticales (Table 2) grown at five locations in Washington during 1984/85 produced more grain than the winter wheats, Stephens and Daws. Flora (a winter triticale) produced the most grain at all locations except Uniontown. Flora was developed and released by Oregon State University. In the spring nurseries at Pullman the triticale, Juan, exceeded the grain production of the spring wheat cultivars Owens and Waverly, and Whitman exceeded the yield of Waverly. Triticale has the same disease problems as wheat. Most of the triticale cultivars and lines tested were resistant to the local races of stripe rust, leaf rust, and stem rust. They are all quite susceptible to *Cephalosporium* stripe. Some of the lines tested were susceptible to ergot.

Promising Triticale

Whitman (VT080011) will be increased for release in 1987. It is a spring triticale but Whitman will survive the winters at Pullman, Washington, if adequate snow cover occurs during the cold weather. Whitman is resistant to the local races of stripe rust and leaf rust. It is susceptible to *Cephalosporium* stripe. Whitman is approximately 15 inches taller than Daws and has a 6 to 10 pound lower bushel weight. It heads earlier than Daws but it matures about the same time. Protein content of the seed of Whitman is generally 1 to 2 percentage points above that of the soft white winter wheat cultivars.

The spring triticale Juan was (developed by CIMMYT and the University of California at Davis) released to the growers in California in 1984. Juan has performed quite well in the Pullman nurseries and therefore, the Washington State Crop Improvement Association increased Juan in Arizona and limited amounts of foundation seed were available in the spring of 1987.

Table 1. Grain yield data (Tons/A) for two winter wheats and four triticales grown for six years in Pullman, WA.

Cultivar	1981	1982	1983	1984	1985	1986	Average
Daws	2.76	2.25	2.37	2.69	1.00	1.68	2.12
Stephens	3.48	2.64	2.49	2.41	0.95	1.02	2.14
Grace*	3.06	1.11	2.43	2.02	1.21	1.18	1.83
Beagle	2.52	1.11	2.16	2.15		0.70	
Whitman	3.24	3.06	3.24	3.18	1.37	1.37	2.58
Juan	3.93	1.80	3.30	2.31		1.82	
Flora			2.46	1.53	1.68		

* Grace and Palouse are the same Triticale and Grace was developed by ARCO.

Table 2. Yield data (Tons/A) on two spring wheats and three triticales grown in Pullman, Washington.

Cultivar	1983	1984	1985	1986	Average
Owens	1.20	1.71	1.29	1.47	1.41
Waverly	1.38	1.68	1.29	0.96	1.32
Grace	0.93	1.53	0.54	1.14	1.05
Whitman	1.38	1.80	1.17	1.02	1.35
Juan	1.41	2.07	1.29	1.17	1.50

SUMMARY OF ACTIVITIES OF THE USDA WESTERN WHEAT QUALITY LABORATORY

Evaluation of end-use milling and baking quality of 2512 experimental wheat germplasm lines (F_5 and later) grown in the western state and harvested as the 1985 crop were made. These included 463 (from WA), 621 (OR), 173 (ID), 911 (CA), 18 (MT), 95 from the Western Regional Nurseries, and 231 from commercial and/or other sources. To date analysis and evaluation has been completed on about 1300 selections from the 1986 crop. Criteria used to determine acceptable quality were standardized tests for flour yield, protein, ash and color; cookie diameter; loaf volume and bread crumb grain; dough mixing requirements and water absorption; Japanese sponge cake volume and texture; and Udon noodle yield, texture, color and score. About 23% of these selections were identified as having promising overall quality to fit their market class. Studies included materials from snowmold, foot rot, dwarf smut, yield trials, various crop management studies, and resistance to salinity stress. These represent new advances to have available improved agronomic germplasm with desirable quality for marketing.

The milling and baking properties of 1469 F_4 generation samples from the 1985 crop breeding programs were evaluated. These experimental wheats were crossed to develop resistance to snow mold, foot rot, dwarf smut, rusts, and adaptability to various crop management practices, and represent all classes except durum and SRW. Tests used to characterize end-use quality were flour yield, break flour yield (soft wheats), kernel hardness, flour protein, mixograph, water absorption and dough properties, and alkaline water retention capacity. About 33% (482) were scored as promising to meet the overall quality of their market classes. About 2,000 micro (10g) F_3 samples were also evaluated for milling quality. About 1,000 crosses made to germplasm sources for sprout resistance were analyzed for alpha-amylase activity. Several of these represent a new generation of germplasm which have both desirable agronomic and end-use quality and are candidates for advancing toward commercial release.

In cooperation with a grant from the PNW Grains Council the milling and baking evaluations were made on commercial composites representing the wheat crop (1985) of Washington, Oregon, and Idaho. The data was used in their marketing brochures. In cooperation with U.S. Wheat Associates, Inc., we participated in a Western White Export Cargo analysis project. The first set of samples was collected from out-going cargos in the fall and winter and contained 51 samples. The second group of 55 samples was collected in the spring, and the third set of 55 samples was collected in the summer. The object of the cargo sample project was to follow the end-use qualities of export shipments through the marketing year. Results show a high degree of uniformity. The next seasonal set is presently being collected. In cooperation with the PNW Grains Council, 5 advanced experimental wheat selections were pilot milled and sent to a group of collaborators for evaluations. These include 4 mills in Japan, 2 in Korea, 1 in The Philippines, 1 in Morocco, 1 in Egypt, and 6 local milling and baking firms. Results of our analysis were published in Dec./86 as the 15th Annual Report of the Pacific Northwest Grains Council Collaborative Tests.

The USDA Western Wheat Quality Laboratory Staff was pleased to have had the opportunity to meet, discuss, and give tours of our facilities with many visitors this past year. This included about 75 U.S. Wheat Workers, Legislators and Government Officials, and 37 foreign visitors.

IMPACT GRAINS PROGRAM
Wheat

In its first year, 1985-86, the state-funded IMPACT Center was of assistance to the Washington wheat industry in a number of ways. Dr. Des O'Rourke, Director, and Ms. Soleil Martel, Administrative Assistant, worked with Keith Sanders in setting up programs for visiting trade teams. Graduate students under the direction of Dr. O'Rourke prepared two small-scale studies on the wheat and barley marketing system.

With the arrival in late 1986 of cereal chemist, Dr. Y. Pomeranz, and agricultural economist, Dr. Terri Raney, the Center has begun a review of its future role in serving the Washington wheat industry. It is important that the Impact Center Address problems that the industry leaders deem important, and that the full capabilities of the scientists are made available to the wheat industry.

Among the services the IMPACT Center can now offer are:

1) A complete one-day program in Pullman for each visiting trade team in conjunction with other WSU scientists: presentations by Pomeranz, Raney, O'Rourke, Sargent, Morrison, Price (nutritional information(, McCullough (business school), etc.; tours of Western Wheat Quality Lab (supervised by Gordon Rubenthaler); provision of student interpreters; provision of promotion packs featuring the Wheat Commission, wheat utilization; scientific support services (Wheat Lab, IMPACT Center, ARC, ARS), appropriate flags and other mementos. The aim is to put together a professional and memorable program for each visitor.

2) Problem-solving research in response to industry queries. The IMPACT Center personnel are willing and able to respond to short-term technical or economic questions raised by the Wheat Commission, Washington wheat industry or customers. This activity would be in cooperation with John Sullivan and Gordon Rubenthaler, etc.

3) Longer-term research. The overall goal here is to tie-in with the existing breeding, agronomic, economic, and milling and baking programs to develop wheats designed to best meet users' needs. Projects might include studies of the constraints on utilization of PNW wheats in Japanese soft type noodles, high quality cookies and crackers, Chinese steamed breads, gravies, soups and thickeners; economic studies of market opportunities for alternatives to soft white wheat such as hard red or hard white; studies of technical and economic problems in specific major country markets including import demand, export competition and barriers to trade.

SOIL FERTILITY MANAGEMENT FOR CROP PRODUCTION IN EASTERN WASHINGTON

F. E. Koehler, W. L. Pan, and E. T. Field

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

No-till management

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

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

In a series of maximum yield experiments over 4 years, the effect of phosphorus fertilizer on winter wheat yields has been studied. Maximum yields exceeded 100 bu/a at 6 of the 17 sites. At two of these high yielding sites where the soil test values for phosphorus were low, there were increases of 8 and 10 bu/a from the addition of phosphorus fertilizer. At the other sites there was little response to phosphorus. These data indicate that eastern Washington growers are doing a good job of maintaining adequate levels of phosphorus in their soil.

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

Hard red spring wheat

N and S requirements of hard red spring wheat for maximum grain yield and % protein is being determined for dryland production. Moisture availability, soil organic matter, and residual N and S in the soil are being considered in modelling the relationship between the fertilizer requirements, yield, and protein.

Peas and lentils

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

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

P availability across a Palouse landscape

Across the rolling topography typical to the Palouse region of Washington significant cereal grain yield reductions have been observed on the ridgetops. In the early 1960's, F. E. Koehler noted that additions of P significantly increased yields on the eroded ridges. Nevertheless, these increased yields still were not comparable to yields obtained in the lower positions. In 1985 field plots of winter barley were established near Pullman with the objectives of characterizing surface and subsoil phosphate levels and to identify yield-limiting factors across a Palouse toposequence.

NaOAc extractable P levels decrease with depth in all positions (Fig. 1). The toeslope position contained the highest P levels with 14 ppm P in the surface layers decreasing to 4 ppm in the subsoil layers. In contrast the sideslope and ridge positions contained 2-5 ppm P in the surface layers decreasing to below 1 ppm in the subsoil.

No significant differences between landscape positions were seen in root length to a depth of 2 ft measured at anthesis. The average root length per 4 in core was 197 in down to 2 ft. Below 2 ft the ridge position had significantly less root growth than the sideslope and toeslope positions. Average root length below 2 ft in the ridge position was 39 in while the sideslope and toeslopes averaged 98 in. The reduced growth in the ridge position was possibly due to a dense restrictive soil layer at a depth of approximately 26 in.

Lower grain yields were obtained at the ridgetop (0.9 T/A) in comparison to the sideslope (1.5 T/A) and the bottomland plots (1.7 T/A). Although this trend is often attributed to greater water stress, we found the amount of available water in the soil profile at the ridgetop to be only slightly less than that at the other positions. However, the low yields were associated with lower P uptake by the crop, despite the fact that 60 lbs P_2O_5/A was applied at planting. Yet the fertilizer P becomes less available as the plow layer dries down during grainfilling, which may cause a late season P stress in regions where subsoil P is deficient.

Soil Acidity

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

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

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

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

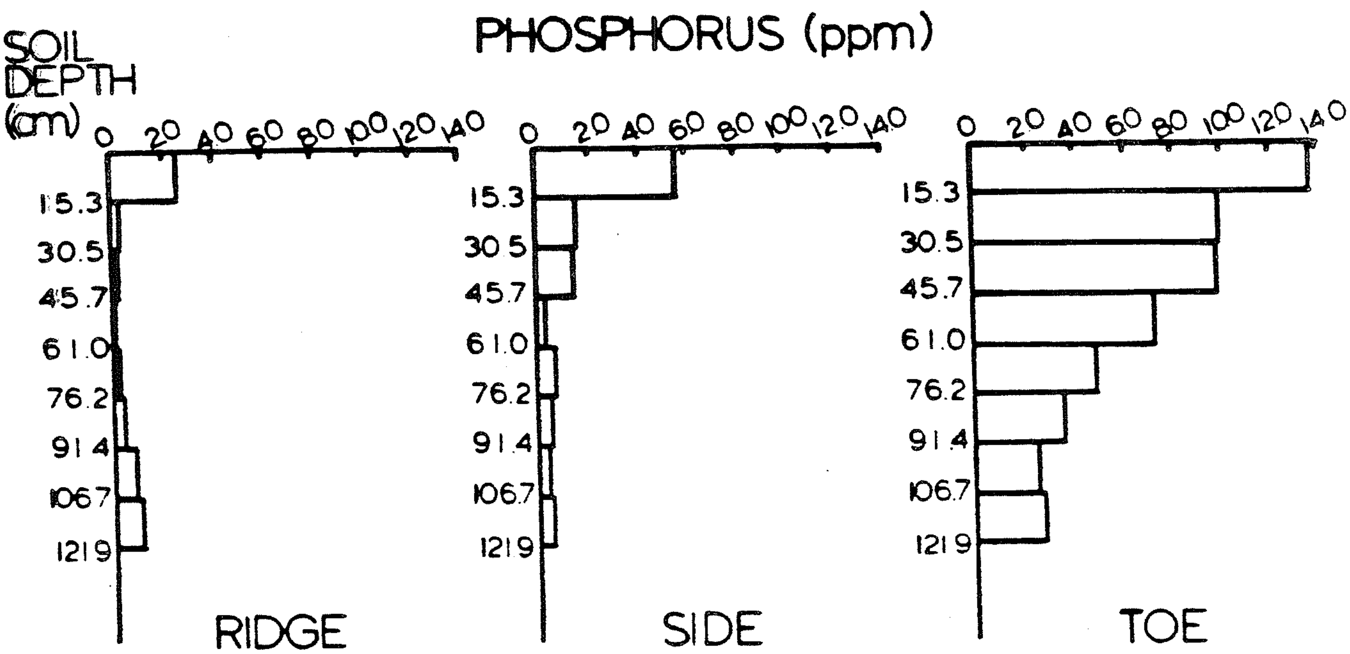


Figure 1. NaOAc extractable P across a Palouse toposequence.

NORDIC AND DOMESTIC SPRING BARLEYS UNDER REDUCED TILLAGE

W. L. Pan, S. E. Ullrich, and E. Tillman

No-till systems are being developed to reduce soil erosion. However, it has been observed that the growth of spring crops is slowed by the cold, wet soil conditions which occur in early spring when plant residues are left on the soil surface. The daytime soil temperatures under no-till can average 10°F lower than a conventionally-tilled soil. The lower soil temperatures decrease root growth and nutrient uptake.

The purpose of this study was to make a comparison among eleven spring barley (Hordeum vulgare) genotypes, including both malt and feed types; seven were obtained from Nordic countries (Sweden, Finland, and Denmark) which are at latitudes further north than Washington and four were developed in the northwestern United States. The far northern-adapted genotypes may be more tolerant to colder soil temperatures which are characteristic of the no-till environment.

Some of the data from the 1986 experiment are summarized in Table 1. Even though Nordal, a Nordic cultivar, had the greatest yield, the following four highest yielders were the four which had been developed in the northwestern United States, all of which were not significantly lower in yield than Nordal. Therefore, the six lowest yielders were Nordic genotypes. The ranking of genotypes for the various grain quality traits measured was in general similar to the ranking for yield. Thus, based on this first year's data, the northwestern United States developed genotypes were as well or better adapted to the cooler, moister no-till conditions of eastern Washington than the Nordic developed and adapted genotypes. Other factors, not only soils conditions, are involved in adaptation and they probably played a major role in the overall performance of the genotypes.

In general growing season air temperatures are higher and rainfall lower in eastern Washington than in the Nordic countries. It was noted that emergence and early seedling growth were in general faster and more vigorous in the Nordic genotypes. These characteristics could be advantageous if incorporated into northwest United States barley cultivars developed for production under conservation tillage.

Table 1. Summary of various grain characteristics of eleven spring barley genotypes produced under no-till conditions in 1986.

Genotype	Malt/ Feed	Row Type	Total grain protein (%)	Test Wt. (lb bu^{-1})	Plump (%)	Yield ($bu\ a^{-1}$)
Nordal(D)[+]	M	2	9.0[f*]	53.2[a]	92[ab]	66[a]
Andre(U)	M	2	9.9[cde]	52.8[ab]	73[de]	64[ab]
Clark(U)	M	2	9.7[de]	52.1[bc]	83[bc]	62[abc]
Steptoe(U)	F	6	10.2[bcd]	50.0[e]	95[a]	60[a-d]
Cougbar(U)	M	6	9.5[ef]	50.5[de]	77[cde]	58[a-e]
HJA80201(F)	M/F	2	10.9[a]	50.5[de]	69[e]	57[b-e]
Pernilla(S)	M/F	2	10.8[a]	52.2[abc]	80[cd]	54[cde]
Gunilla(S)	M/F	2	10.7[ab]	51.5[cd]	69[e]	53[def]
Agneta(U)	M/F	6	10.4[abc]	48.4[f]	68[e]	54[cde]
HJA78003(F)	M/F	6	9.1[f]	48.6[f]	50[f]	51[ef]
HJA Potra(F)	M	6	10.8[ab]	48.6[f]	74[cde]	45[f]

[+] U = USA; S = Sweden; D= Denmark; F - Finland

[*] Genotypes followed by the same letter are not significantly different at P = 0.05 according to LSD.

HYDROLOGIC RESEARCH

K. E. Saxton

Research related to dryland water management has continued this past year on the following topics:

Residue and tillage management impacts and options:

The choice of tillage and residue management methods can greatly influence the infiltration and storage of precipitation. We have developed new computer methods which allow the calculation of simultaneous heat and water (SHAW) budgets for soil for a wide range of tillage and residue combinations. Field measurements on controlled plots verify that these calculations are realistic. The results are being used in two major studies: first to predict soil water freezing which is a major contributor in the runoff and erosion of our region and secondly to study soil water evaporation in fallow conditions to define the benefits and options of tillage and residue combinations. These combination field and model studies show both the impact of the management options and the physical reasons to aid further research and recommendations.

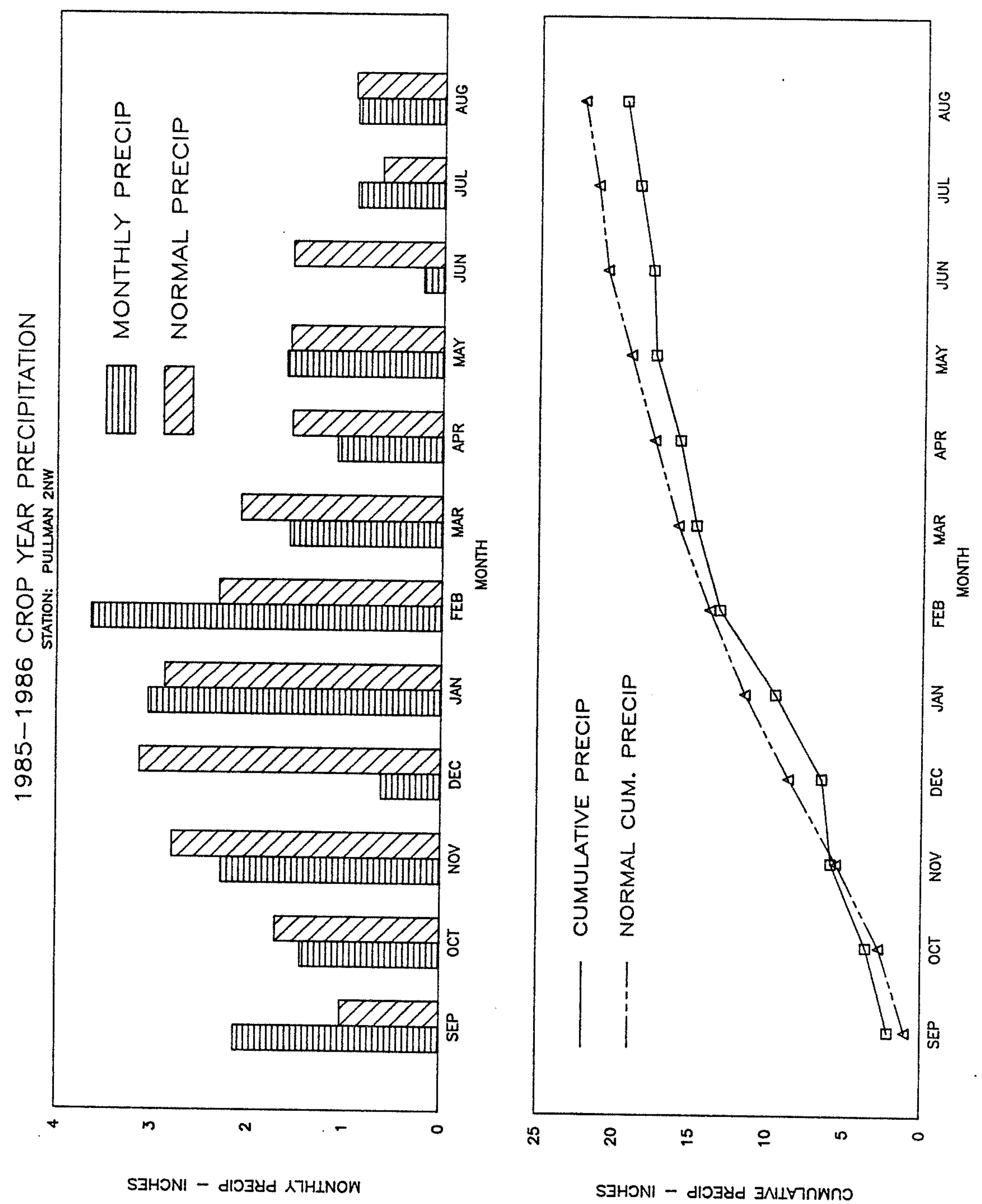
Conservation tillage methods and machines:

Conservation tillage through minimal tillage and residue management remains one of our strongest conservation tools. We have continued to investigate direct seeding drills and their interaction with untilled soil and surface residues. Several different openers have been constructed, mounted on a test drill, and detailed measurements made of their performance. In recent months, a single coulter opener from New Zealand (the Bio-blade opener) was mounted and tested for direct seeding with quite promising results for both seed and fertilizer placement. Testing and trials will continue.

Several other tillage tools and methods related to conservation tillage continue to be developed and/or tested. Machines to perform slot-mulching for excess residue disposal and improved water infiltration are being tested. Additional tests with the Paraplow, a slant-legged chisel, continue to show good advantage for leaving surface residues, a reasonably smooth soil surface, and a well fractured soil for good water infiltration. Tests near Winona over three years clearly demonstrated significantly increased over-winter soil water storage where the Paraplow was used and the stubble left standing. It appears this implement could have a definite place in conservation tillage. Other implements such as the Dammer-Diker and a pitting-disc are being reviewed for potential application to dryland fields.

Historic and current weather:

Weather for dryland farmers is of paramount importance for crop production. The impacts are, of course, actually related through the available stored soil water and the evaporative demands placed on the crops. Through increased computer capability, we are now able to more fully and rapidly analyze historic (normal) and current weather. The following graphs and tables are examples which are particularly interesting in this dryer-than-normal year. The numbers readily demonstrate the amounts and trends of precipitation and temperatures the past and current crop years. Three stations across the Palouse (Pullman, LaCrosse, and Lind) are analyzed and reported each month.


1985–1986 CROP YEAR PRECIPITATION
STATION: PULLMAN 2NW
MONTHLY PRECIP
NORMAL PRECIP
MONTHLY PRECIP – INCHES
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CUMULATIVE PRECIP
NORMAL CUM. PRECIP
CUMULATIVE PRECIP – INCHES
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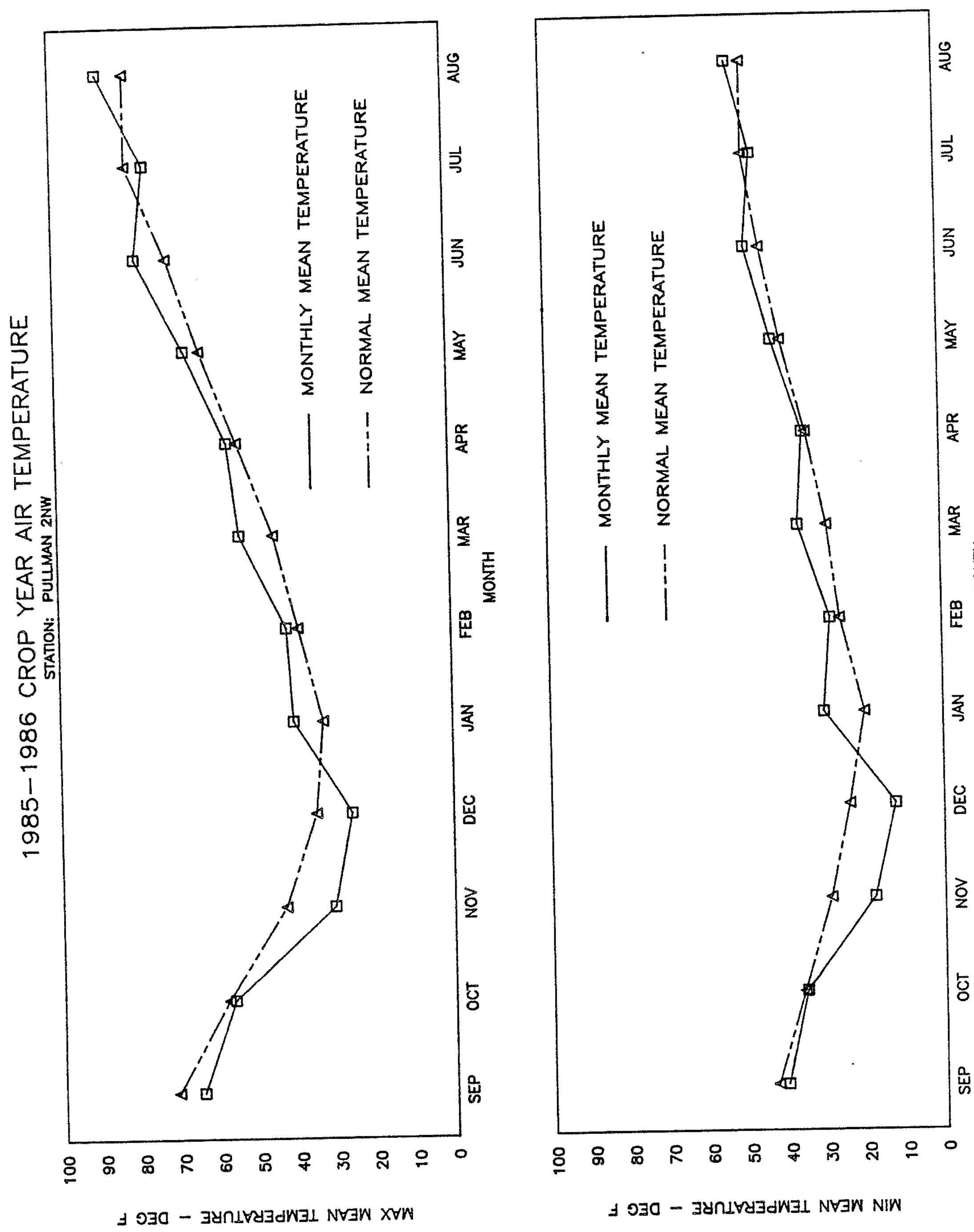
1985-1986 CROP YEAR AIR TEMPERATURE
STATION: PULLMAN 2NW
MONTHLY MEAN TEMPERATURE
NORMAL MEAN TEMPERATURE
MAX MEAN TEMPERATURE - DEG F
MIN MEAN TEMPERATURE - DEG F
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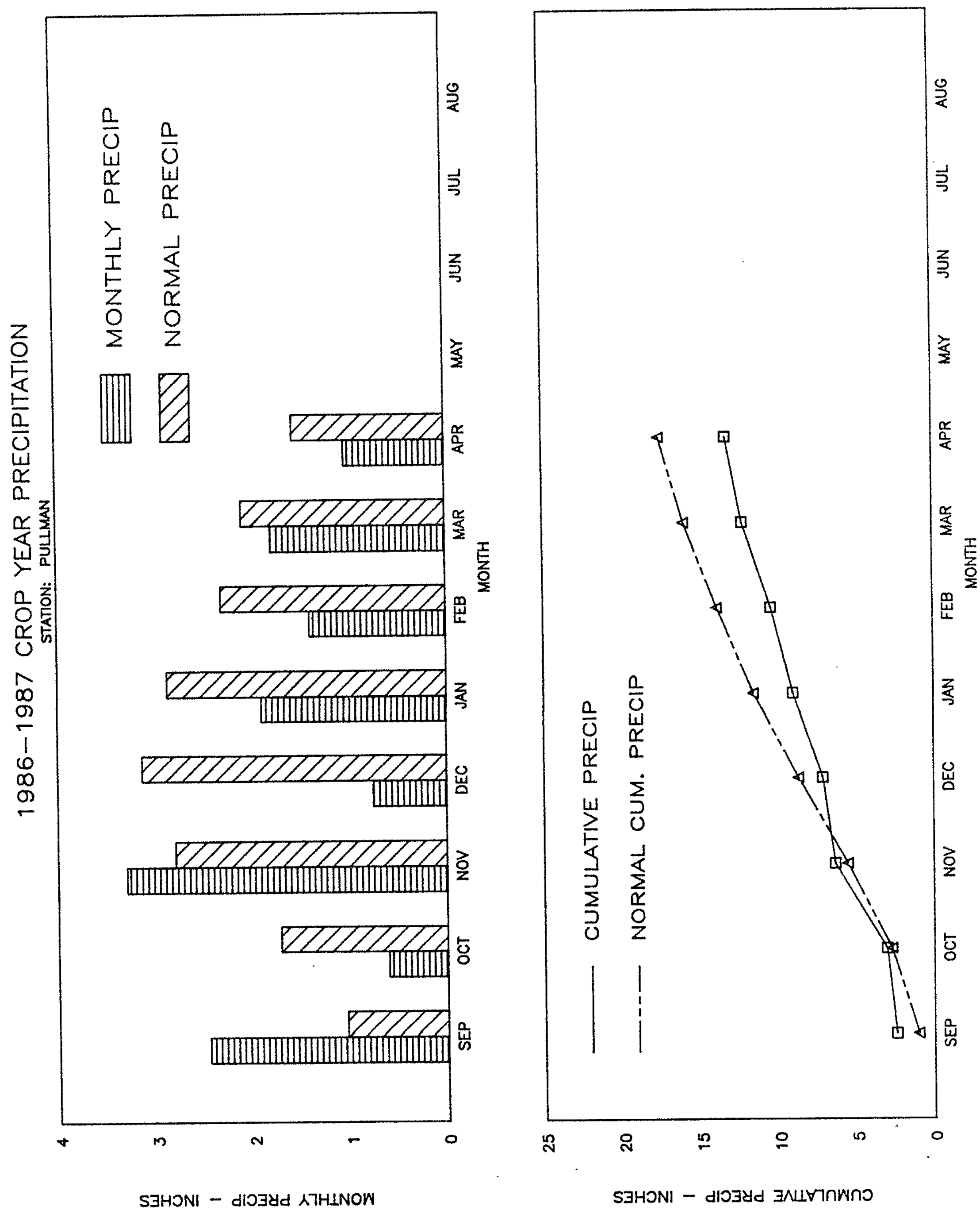
1986–1987 CROP YEAR PRECIPITATION
STATION: PULLMAN
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NORMAL PRECIP
MONTHLY PRECIP – INCHES
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NORMAL CUM. PRECIP
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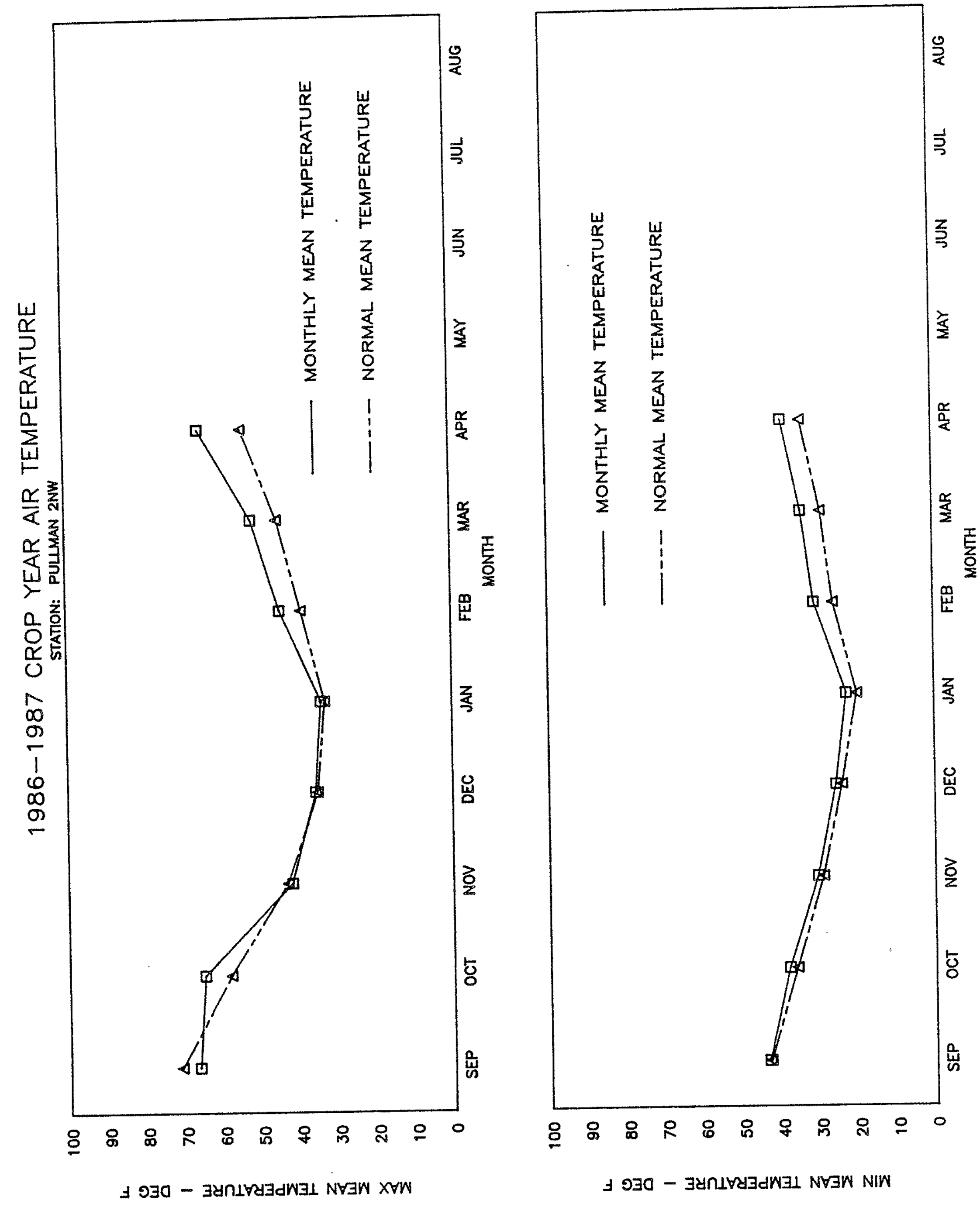
1986-1987 CROP YEAR AIR TEMPERATURE
STATION: PULLMAN 2NW
MAX MEAN TEMPERATURE - DEG F
MIN MEAN TEMPERATURE - DEG F
MONTHLY MEAN TEMPERATURE
NORMAL MEAN TEMPERATURE
MONTHLY MEAN TEMPERATURE
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MONTHLY WEATHER SUMMARY APRIL 1987 STATION: PULLMAN 2NW

DAY	AIR TEMP (deg F) MAX	MIN	PRECIP (in) DAILY	SNOW (in) DAILY	ON_GND	PAN EVAP * (in) DAILY	MINIMUM SOIL TEMP (deg F) DEPTH(in) 2	4	8	GROWING DEGREE DAYS 32 deg F DAILY	CUM	37.4 deg F DAILY	CUM	HEATING DEGREE DAYS 65 deg F DAILY	CUM
1	70.	32.	0.00	0.0	0.0	0.00	38.	40	42	19.	19.	14.	14.	14	14
2	71.	39.	0.00	0.0	0.0	0.00	40.	42	43	23.	42.	18.	32.	10	24
3	66.	41.	0.00	0.0	0.0	0.00	44.	45.	45.	22.	64.	16.	48.	11.	35.
4	60.	36.	0.00	0.0	0.0	0.00	43.	46.	46.	16.	80.	11.	59.	17.	52.
5	61.	44.	0.00	0.0	0.0	0.00	47	48.	47.	21.	101.	15.	74.	12.	64.
6	63.	40	0.00	0.0	0.0	0.00	45.	47.	48.	20.	121.	14.	88.	13	77
7	62	42	.02	0.0	0.0	0.00	48.	49.	49.	20.	141	15.	103.	13	90
8	53.	36.	.22	0.0	0.0	0.00	43.	47.	48	13	154	7.	110	20	110.
9	56.	30.	.02	0.0	0.0	0.00	39.	43.	45	11	165.	6.	116.	22.	132.
10	63.	36	0.00	0.0	0.0	0.00	42	44	45	18	183	12.	128	15.	147.
11	49	33.	.45	0.0	0.0	0.00	40	43	45.	9.	192.	3.	131.	24.	171.
12	52.	31	.02	0.0	0.0	0.00	38.	42.	44.	10.	202.	4.	135.	23.	194.
13	61.	31.	0.00	0.0	0.0	0.00	38.	41.	43.	14.	216.	9.	144.	19.	213.
14	67.	42.	0.00	0.0	0.0	0.00	44.	45.	46.	23	239.	17.	161	10	223.
15	60.	46.	0.00	0.0	0.0	0.00	47.	48.	48.	21.	260.	16.	177.	12.	235.
16	64.	44.	0.00	0.0	0.0	0.00	47.	48.	48.	22.	282	17.	194.	11.	246.
17	59.	37.	0.00	0.0	0.0	0.00	47.	49.	49.	16.	298.	11.	205.	17.	263.
18	49.	32.	.09	0.0	0.0	0.00	42.	45.	47.	9.	307.	3.	208.	24.	287.
19	53.	29.	0.00	0.0	0.0	0.00	39	42.	45.	9.	316.	4.	212.	24.	311.
20	62.	31.	0.00	0.0	0.0	0.00	40.	43.	46.	15.	331.	9.	221.	18.	329
21	75.	35.	0.00	0.0	0.0	0.00	44.	47.	48.	23.	354.	18.	239.	10.	339.
22	71.	40.	0.00	0.0	0.0	0.00	48	50.	50.	24	378.	18.	257.	9.	348.
23	71.	47.	0.00	0.0	0.0	0.00	52.	53.	52.	27.	405.	22.	279.	6.	354.
24	68.	40.	0.00	0.0	0.0	0.00	50.	53.	53.	22.	427.	17.	296.	11.	365.
25	67.	37.	0.00	0.0	0.0	0.00	52.	54.	54.	20.	447.	15.	311.	13.	378.
26	79.	35.	0.00	0.0	0.0	0.00	49.	53.	54.	25.	472.	20.	331.	8.	386.
27	87.	48.	0.00	0.0	0.0	0.00	54.	56.	56.	36.	508.	30.	361.	0.	386.
28	86.	52.	0.00	0.0	0.0	0.00	58.	59.	59.	37.	545.	32.	393.	0.	386.
29	79.	56.	.07	0.0	0.0	0.00	58.	59.	59.	36.	581.	30.	423.	0.	386.
30	71.	45.	.14	0.0	0.0	0.00	54.	58.	59.	26.	607.	21.	444.	7.	393.

-----SUMMARY-----

	PRECIP(in)	SNOWFALL(in)	PAN EVAP(in)	GROWING DEGREE DAYS 32 deg	37.4 deg	HEATING DEGREE DAYS 65 DEG
MONTHLY TOTAL	1.03	0.0	0.00	607.	444.	393.
NORMAL	1.56			387.	213.	604.
DEP FROM NORM	-.53			220.	231.	-211.
TOTAL SINCE 01 JAN	6.12	11.0	0.00	1179.	685.	2953.
NORMAL	8.83			769.	331.	3493.
DEP FROM NORM	-2.71			410.	354.	-540.
TOTAL SINCE 01 SEP	13.21	18.2		2698.	1713.	5582.
NORMAL	17.49			2260.	1299.	6247.
DEP FROM NORM	-4.28			438.	414.	-665.

	AIR TEMP (deg F) MAX	MIN	MIN SOIL TEMP (deg F) 2 in	4 in	8 in
MONTHLY MEAN	65.1	38.9	45.7	48.0	48.8
NORMAL	54.0	34.0			
DEP FROM NORM	11.1	4.9			

PRECIP = RAIN, MELTED SNOW, ETC.

MAX-MIN TEMPERATURES ARE ON A MIDNIGHT-MIDNIGHT BASIS

NORMAL VALUES ARE BASED ON A 38-YEAR AVERAGE (1948-1985)

NEGATIVE VALUES (-99 FOR TEMPERATURES) DENOTE MISSING VALUES

* PAN EVAPORATION READINGS ARE TAKEN ONLY FROM 01 MAY THROUGH 31 OCTOBER

MONTHLY WEATHER SUMMARY   APRIL   1987   STATION   LIND 3NE

DAY	AIR TEMP (deg F) MAX	AIR TEMP (deg F) MIN	PRECIP (in) DAILY	SNOW (in) DAILY	SNOW (in) ON_GND	PAN EVAP* (in) DAILY	GROWING DEGREE DAYS 32 deg F DAILY	GROWING DEGREE DAYS 32 deg F CUM	GROWING DEGREE DAYS 37.4 deg F DAILY	GROWING DEGREE DAYS 37.4 deg F CUM	HEATING DEGREE DAYS 65 deg F DAILY	HEATING DEGREE DAYS 65 deg F CUM
1	74.	33.	0.00	0 0	0 0	.15	22	22.	16.	16	11.	11.
2	73.	43.	0.00	0 0	0.0	.30	26.	48	21.	37.	7	18.
3	69.	44.	0.00	0.0	0.0	.23	25.	73.	19.	56.	8	26.
4	64.	40.	0.00	0.0	0.0	.19	20.	93.	15.	71.	13.	39.
5	63	41.	0.00	0 0	0.0	.20	20.	113.	15.	86.	13.	52.
6	62.	37.	0.00	0.0	0.0	.12	18.	131.	12.	98.	15.	67.
7	64.	43.	0.00	0.0	0 0	.22	22.	153.	16.	114.	11.	78.
8	64.	39.	.07	0.0	0.0	.27	20.	173.	14.	128.	13	91.
9	58.	28	0.00	0.0	0.0	.24	11.	184.	5.	134.	22	113
10	64.	39.	0.00	0.0	0.0	.15	20.	204.	14.	148.	13.	126
11	53.	32.	.22	0.0	0.0	0.00	11.	215.	5.	153	22.	148.
12	56.	31	0.00	0.0	0.0	.15	12.	227.	6.	159.	21	169.
13	66.	35.	0 00	0.0	0.0	.23	19.	246.	13.	172.	14	183.
14	70.	43.	0.00	0.0	0.0	.26	25.	271.	19.	191.	8.	191.
15	69.	49.	0.00	0.0	0.0	.22	27.	298.	22.	213.	6.	197.
16	61.	48.	0.00	0.0	0.0	.18	23.	321.	17.	230.	10.	207.
17	61	44.	.07	0.0	0.0	0.00	21.	342.	15.	245.	12.	219.
18	54.	30.	.13	0.0	0.0	.10	10.	352.	5.	250.	23.	242.
19	55.	26.	0.00	0.0	0.0	.20	9.	361.	3.	253.	24.	266.
20	63.	28.	0.00	0.0	0.0	.25	14.	375.	8.	261.	19.	285.
21	73.	33.	0.00	0.0	0.0	.19	21.	396.	16.	277.	12.	297.
22	71.	39	0.00	0.0	0.0	.20	23.	419.	18.	295.	10.	307.
23	71.	44.	0.00	0.0	0.0	.28	26.	445.	20.	315.	7.	314.
24	71.	38.	0.00	0.0	0.0	.22	23.	468.	17.	332.	10.	324.
25	69.	36.	0.00	0.0	0.0	.25	21.	489.	15.	347	12.	336.
26	83	36.	0.00	0.0	0.0	.30	28.	517.	22.	369.	5.	341.
27	90.	50.	0.00	0 0	0.0	.34	38.	555.	33.	402.	0.	341.
28	88.	60.	0.00	0.0	0.0	.43	42.	597.	37.	439.	0.	341.
29	84.	56	0.00	0.0	0.0	.35	38.	635.	33.	472.	0.	341.
30	79.	55.	.05	0.0	0.0	.21	35.	670.	30.	502.	0.	341.

---SUMMARY---

	PRECIP(in)	SNOWFALL(in)	PAN EVAP(in)	GROWING DEGREE DAYS 32 DEG	GROWING DEGREE DAYS 37.4 DEG	HEATING DEGREE DAYS 65 DEG
MONTHLY TOTAL	.54	0.0	6.43	670.	502.	341.
NORMAL	.70		5.69	480.	302.	510.
DEP FROM NORM	-.16		.74	190.	200.	-169.
TOTAL SINCE 01 JAN	2.73	16.0	6.43	1264.	776.	2875
NORMAL	3.42		5.69	996.	508.	3245.
DEP FROM NORM	-.69		.74	268.	268.	-370.
TOTAL SINCE 01 SEP	5.32	20.5		2899.	1935.	5411.
NORMAL	7.29			2713.	2247.	5756.
DEP FROM NORM	-1.97			186.	-312.	-345.

	AIR TEMP (deg F) MAX	AIR TEMP (deg F) MIN
MONTHLY MEAN	68.1	40.0
NORMAL	61.0	33.0
DEP FROM NORM	7.1	7.0

PRECIP = RAIN, MELTED SNOW, ETC.

NORMAL VALUES ARE BASED ON A 38-YEAR AVERAGE (1948-1985)

NEGATIVE VALUES (-99 FOR TEMPERATURES) DENOTE MISSING VALUES

* PAN EVAPORATION READINGS ARE TAKEN ONLY FROM 01 APRIL THROUGH 30 SEPTEMBER

MONTHLY WEATHER SUMMARY APRIL 1987 STATION LACROSSE

DAY	AIR TEMP (deg F) MAX	AIR TEMP (deg F) MIN	PRECIP (in) DAILY	SNOW (in) DAILY	GROWING DEGREE DAY 32 deg F DAILY	GROWING DEGREE DAY 32 deg F CUM	GROWING DEGREE DAY 37 4 deg F DAILY	GROWING DEGREE DAY 37 4 deg F CUM	HEATING DEGREE DAYS 65 deg F DAILY	HEATING DEGREE DAYS 65 deg F CUM
1	75.	33.	0.00	0.0	22.	22.	17.	17.	11.	11.
2	77.	39	0.00	0.0	26.	48.	20	37.	7.	18
3	67.	35.	0.00	0.0	19.	67.	14.	51.	14.	32
4	63.	43.	0.00	0.0	21.	89.	16.	67.	12.	44.
5	64	40.	0.00	0.0	20.	108.	15.	82.	13.	57.
6	66.	40.	0.00	0.0	21.	129.	16.	98.	12.	69.
7	64.	42.	0.00	0.0	21.	150.	16.	114.	12.	81.
8	59.	44	.05	0.0	20.	170.	14.	128.	13	94.
9	59.	57.	0.00	0.0	26.	196.	21.	149.	7.	101.
10	68.	39.	.10	0.0	22.	218.	16.	165.	11.	112.
11	53.	34.	.36	0.0	12.	230.	6.	171.	21.	133.
12	56.	32.	0.00	0.0	12.	242.	7.	178.	21.	154.
13	68.	34.	0.00	0.0	19.	261.	14.	192.	14.	168.
14	70.	44.	0.00	0.0	25.	286.	20.	212.	8.	176.
15	67.	47.	0.00	0.0	25.	311.	20.	232.	8.	184.
16	63.	50.	0.00	0.0	25.	336.	19.	251.	8.	192.
17	60.	47.	0.00	0.0	22.	358.	16.	267.	11.	203.
18	53.	33.	0.00	0.0	11.	369.	6.	273.	22.	225.
19	55.	28.	.05	0.0	10.	379.	4.	277.	23.	248.
20	66.	27.	0.00	0.0	15.	394.	9.	286.	18.	266.
21	74.	33.	.10	0.0	22.	416.	16.	302.	11.	277.
22	73.	36.	.36	0.0	23.	439.	17.	319.	10.	287.
23	72.	44.	0.00	0.0	26.	465.	21.	340.	7.	294.
24	71.	37.	0.00	0.0	22.	487.	17.	357.	11.	305.
25	69.	37.	0.00	0.0	21.	508.	16.	373.	12.	317.
26	86.	34.	0.00	0.0	28.	536.	23.	396.	5.	322.
27	94.	41.	0.00	0.0	36.	572.	30.	426.	0.	322.
28	91.	57.	.10	0.0	42.	614.	37.	463.	0.	322
29	86.	53.	.06	0.0	38.	652.	32.	495.	0.	322.
30	77.	55.	0.00	0.0	34.	686.	29.	524.	0.	322.

---SUMMARY---

	PRECIP(in)	SNOWFALL(in)	GROWING DEGREE DAYS 32 DEG	GROWING DEGREE DAYS 37.4 DEG	HEATING DEGREE DAYS 65 DEG
MONTHLY TOTAL	1.18	0.0	686.	524.	322.
NORMAL	.97		473.	296.	519.
DEP FROM NORM	.21		213.	228.	-197.
TOTAL SINCE 01 JAN	3.79	5.9	1326.	837.	2738.
NORMAL	5.39		1035.	525.	3183.
DEP FROM NORM	-1.60		291.	312.	-445.
TOTAL SINCE 01 SEP	7.51	7.1	2962	1965.	5191.
NORMAL	11.09		2745	1675.	5689.
DEP FROM NORM	-3.58		217.	290.	-498.

	AIR TEMP (deg F) MAX	AIR TEMP (deg F) MIN
MONTHLY MEAN	68.9	40.5
NORMAL	60.0	34.0
DEP FROM NORM	8.9	6.5

PRECIP = RAIN, MELTED SNOW, ETC.

NORMAL VALUES ARE BASED ON A 38-YEAR AVERAGE (1948-1985)

NEGATIVE VALUES (-99 FOR TEMPERATURES) DENOTE MISSING VALUES

RUNOFF AND EROSION PREDICTION

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

The cross-compliance provisions of the 1985 Farm Bill have highlighted the importance of accurate erosion prediction. If predictions are too high, producers will be unjustly denied participation in commodity and other programs. If predictions are too low, the on-site and off-site resources will be inadequately protected. Improving erosion prediction is an important mission of the Land Management and Water Conservation Research Unit at Pullman.

Eight years of runoff plot data from the Palouse Conservation Field Station and nine years of runoff plot data from the Columbia Plateau Conservation Research Station at Pendleton have been analyzed and a surface residue effectiveness curve developed. The curve indicates surface residues to be more effective at controlling rill erosion than the Midwestern relationship currently in use. The new relationship will vastly improve the accuracy of erosion prediction on rainfed cropland of the Pacific Northwest and increase the options available to meet the compliance provisions of the 1985 Farm Bill.

Analysis has been completed on 10 years of rill erosion data collected from rainfed cropland of the Pacific Northwest. The analysis produced revised slope length, steepness, and equivalent erosivity relationships for the region.

A simple photographic technique proved effective for determining percent of the soil surface covered by crop residue or growing cover. The technique was also used to determine the amount of residue buried by various common tillage implements.

An initial series of tests conducted in the frozen soil flume has produced critical shear stress and detachment coefficients for soil frozen and thawed at three soil moisture tensions. These critical shear values are greater than zero, but lower than values for freshly tilled soils in the Midwest. The results of this study will improve soil erodibility determinations and hence the accuracy of erosion prediction.

INHIBITION OF WINTER WHEAT AND WEED GROWTH BY ROOT COLONIZING BACTERIA

L. F. Elliott, A. C. Kennedy
K. A. Kaufmann, and R. I. Papendick

Large numbers of bacteria inhibitory to winter wheat growth can be present on wheat root surface. These bacteria (members of a group called pseudomonads) are aggressive root colonizers which normally appear in large numbers on the root surface after the plants break dormancy in the early spring. We have sampled fields where all of the pseudomonads on the root surfaces were inhibitory. Cold, wet springs seem to encourage the bacteria. They inhibit winter wheat growth by producing a toxin.

Seeding into heavy wheat residue (till or no-till) seems to encourage the presence of these bacteria on the root surface. Inhibitory isolates of the bacteria will colonize various straws and remain on it for long periods of time. In no-till seeding into heavy residue, severe stand loss usually occurs in the chaff row. The inhibitory bacteria grow well on chaff and large numbers have been isolated from chaff in the field.

Crop rotations may be an effective control measure for these inhibitory pseudomonads. Although the bacteria can grow on the root surface and residues of various Palouse crop plants, damage by these specific organisms appears most severe to winter wheat.

Field studies show that winter wheat inoculated with these pseudomonads in nonsterile soil produce inhibited plants with an overwinter stand loss up to 50% and a reduced yield. In another field study, the pseudomonads were sprayed onto barley residue, which was either plowed under or left on the soil surface, and planted to winter wheat. The organisms colonized the wheat root surfaces and root-shoot ratios were reduced. This study provides direct evidence that inhibitory pseudomonads on straw from the previous crop can colonize the roots of wheat sown into it.

Similar bacteria have been isolated that inhibit downy brome germination and root growth, and root growth of goat grass. Inhibition has been shown in laboratory and greenhouse studies. Field studies are underway.

Work is proceeding in the field on the effect of crop rotations on the presence of these pseudomonads on root surfaces and on residue-microbial relationships. Other areas also being studied are: purification, identification, mode of action of the toxin, and the genetic control of toxin production.

Partial support of this research project by the O.A. Vogel Fund is gratefully acknowledged.

CONTROL OF DOWNY BROME (CHEATGRASS) IN WINTER WHEAT

D. G. Swan and R. E. Whitesides

Seven downy brome experiments were conducted at seven diverse locations in eastern Washington from 1981 through 1985. These studies compared metribuzin (Lexone or Sencor) with and without terbutryn (Igran) applied both fall and spring to control downy brome in winter wheat. Rates used were metribuzin at 0.38 lb/A a.i. and metribuzin at 0.25 plus terbutryn at 0.6 lb/A a.i. (tank mixed). Information obtained was visual crop symptoms, weed control and wheat yields.

Results showed three crop symptoms: reduced crop stand, suppressed crop growth and discoloration. These symptoms appeared alone or in combination. Crop symptoms averaged 10% when the herbicides were applied in the fall and 4% when applied in the spring. Metribuzin + terbutryn, fall applied, gave best downy brome control (Figure 1). When the herbicides were applied in the fall, downy brome control averaged 30% more than when they were applied in the spring. Wheat yields are shown in Figure 2. Only plots treated with metribuzin + terbutryn in the fall were significantly higher yielding than the check at all locations for all years. Other treatments resulted in significantly higher yields only at some locations or years.

The downy brome population ranged from 2 to 11 plants per square foot. These weeds caused yield reductions ranging from 2.3% to 10% per weed per square foot. This gave an average yield reduction of 31% (on a per acre basis) in these experiments.

It is estimated that at least 15% of the winter wheat acreage in eastern Washington is infested with downy brome. It is not known how much higher the 60 bushel per acre average wheat yield might be if we could control the downy brome.

Figure 1: Downy Brome Control

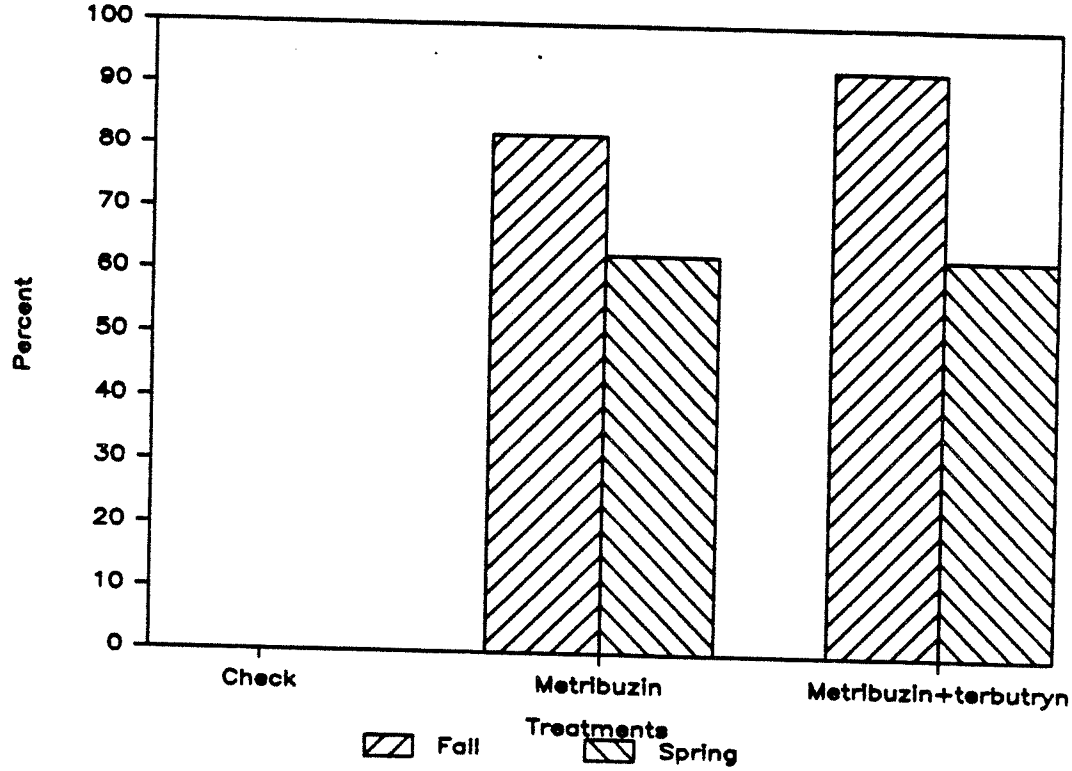
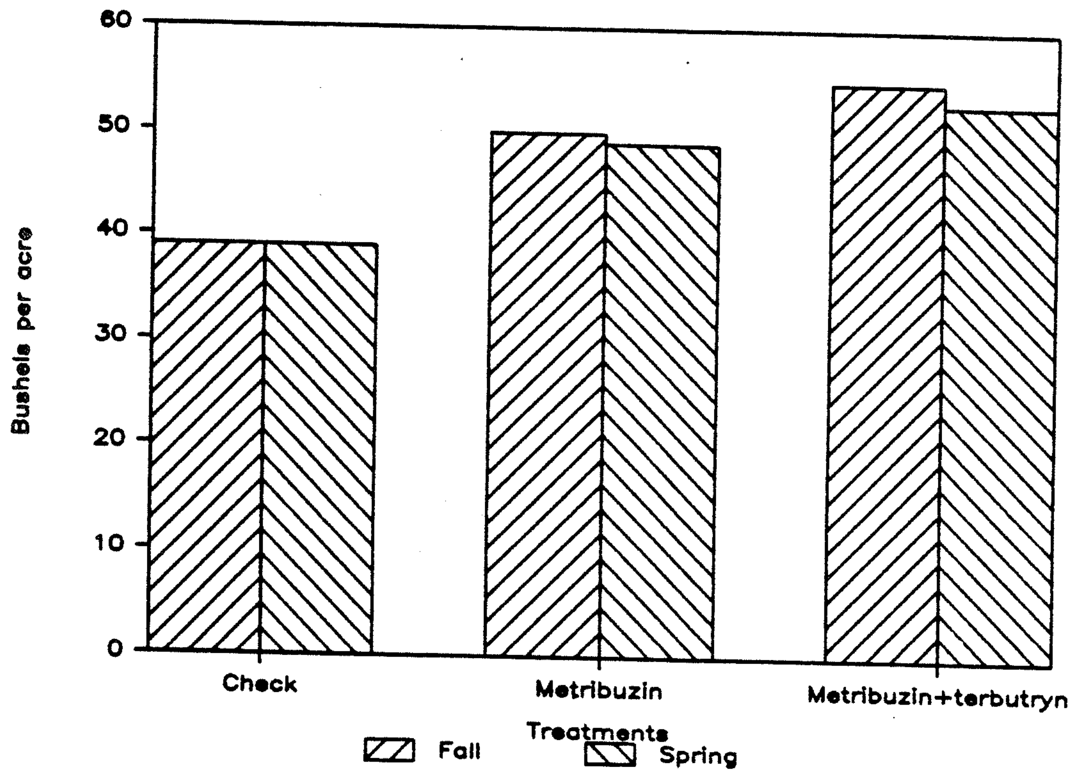


Figure 2: Winter Wheat Yields



DOWNY BROME CONTROL IN WINTER WHEAT

A. G. Ogg

Downy brome is the most widespread weed in eastern Washington wheat fields. Downy brome is a "crop-mimic" weed in that it emerges about the same time as winter wheat and its growth cycle is similar to winter wheat, except that it matures seed earlier than does the wheat. In spite of many years of research, downy brome continues to be a serious weed problem in winter wheat.

Currently, there are no herbicides which will consistently control downy brome selectively in winter wheat. However, triallate (Fargo) and diclofop (Hoelon) will suppress downy brome when applied and incorporated shallowly before planting winter wheat. These two herbicides are registered for use in winter wheat. Metribuzin (Sencor/Lexone) applied postemergence after the wheat has developed secondary roots at least 2 inches long will control seedling downy brome. Successful control of downy brome with metribuzin depends upon several factors including a size differential between the wheat and the weed and adequate moisture soon after the herbicide is applied. Fall applications of metribuzin have controlled downy brome better than spring applications.f However, metribuzin applied in the fall sometimes injures winter wheat and wheat yields can be suppressed.

Recently, an experimental herbicide, the ethio-analog of metribuzin, has shown promise for the control of downy brome in winter wheat. This herbicide is being developed by DuPont under the trade name of Seige and by Mobay under the trade name Tycor. Winter wheat is significantly more tolerant to Seige/Tycor than it is to metribuzin. Seige/Tycor is less active and has shorter soil residual than metribuzin; therefore, at least 0.75 lbai/A of Seige/Tycor is usually required for effective control of downy brome. Also, rainfall within one week after application appears to be necessary for effective control.

Research was begun in 1985 to determine the optimum rate and timing of Seige/Tycor applications to maximize the control of downy brome in winter wheat. Also, low rates of metribuzin in combination with Seige/Tycor at various rates are being evaluated to determine if the rate of Seige/Tycor can be reduced and thus make the treatment more economical.

Downy brome control with currently available herbicides (Fargo, Hoelon, Lexone/Sencor) and with experimental herbicides (Seige/Tycor, atrazine, Fargo-Treflan granules) will be shown and discussed at the Dryland Research Unit at Lind, WA.

STRAWBREAKER FOOT ROT AND CEPHALOSPORIUM STRIPE

T.D. Murray, C. Campbell, J.C. Anderegg, and C. Strausbaugh

Strawbreaker foot rot and Cephalosporium stripe are important diseases of winter wheat, especially wheat that is early seeded on summer fallow. Both diseases are most prevalent in the intermediate (≥16" annual precipitation) and high rainfall areas of eastern Washington, and both are favored by short rotations and wet autumn weather. Yield losses of 50% can occur with strawbreaker and up to 100% when cephalosporium stripe is serious.

Strawbreaker foot rot is currently controlled by a single application of a fungicide in the spring. Three fungicides are registered for use in Washington Benlate, Mertect, and Topsin. Under mild to moderate disease pressure, these three fungicides will give comparable control and yield responses. One of the goals of this research program is to screen new fungicides for use either in combination with current fungicides, or as replacements. The fungus that causes foot rot can develop resistance to these fungicides and has in other parts of the world. Prochloraz is a fungicide that has been used in Europe where resistance to Benlate, Mertect, and Topsin has occurred. The combination treatment of Benlate + Prochloraz has been the top performer over the past two years in experimental trials. It may be possible to introduce this combination for commercial use in about 3 years.

Another control for strawbreaker foot rot is resistant varieties. Resistance is difficult to breed for and is not well-understood. We are studying resistance to try and understand what makes a plant resistant. So far we have correlated adult-plant resistance with seedling resistance. This allows us to study resistance in the seedling stage and speed up development of tests for resistance. Currently we are studying the inheritance of several characteristics of seedlings that are correlated with resistance. The goal is to develop a fast, inexpensive test for resistance that can be used on large populations of plants.

Cephalosporium stripe cannot be controlled with fungicides. The best control for this disease is crop rotations with nonhosts. Rotation crops can include spring wheat or barley, lentils, peas, or rape. To be effective, rotations should provide two years out of winter wheat (or winter barley).

Resistance is another control for cephalosporium stripe. Like strawbreaker, however, it is difficult to breed for resistance to cephalosporium stripe. In the past, it has been difficult to get uniform testing of potential varieties due to variation in disease severity in field plots. Increasing soil acidity has been found to increase the incidence and severity of cephalosporium stripe. Tests are now being conducted in the greenhouse to determine if we can use increased soil acidity to increase disease and screen for resistance. Experiments are also being conducted in the field to determine the potential for controlling cephalosporium stripe by liming. Results of last year's field test showed that disease was reduced by 50% when soil pH was raised above pH 6.0, with a corresponding yield increase of 5 bu/ac.

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

R. F. Line

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

Historical Importance. In the late 1950's and early 1960's stripe rust caused losses in excess of 50 percent. Destructive epidemics of the rust have occurred in fields of susceptible varieties in 18 of the last 24 years. Stripe rust reduced yields in the Pacific Northwest by more than 20 percent in 1981 and more than 15 percent in 1983. Without development of resistant varieties and emergency registration of a fungicide (Bayleton) for rust control. Losses would have exceeded 50 percent in 1981 and 30 percent in 1983 and 1984. As we develop varieties with better stripe rust resistance, leaf rust becomes more important because tissue not damaged by stripe rust is damaged by the later developing leaf rust. Consequently, leaf rust has become increasingly more important since 1962. In 1974, losses in Twin spring wheat exceeded 50 percent. Within the last 13 years, leaf rust has caused severe losses in every year except 1977, 1979, 1982, 1985, and 1986. Leaf rust is consistently severe in irrigated fields, and losses caused by the rust in those fields have sometimes exceeded 60 percent. In 1980 and 1984, stem rust caused significant damage to wheat in eastern Washington and Oregon and northern Idaho, especially in late maturing fields.

Monitoring Rust. Thirty-two races of *Puccinia striiformis*, the pathogen which causes stripe rust, have been identified. Races virulent on Fielder, Moro, Jacmar, Barbee, Faro, Weston, Tyee, and seedlings of Stephens, Hill 81, and Daws were most prevalent in the Pacific Northwest. No significant new races of *Puccinia recondita*, the pathogen causing leaf rust, were detected in 1986. Most winter wheat varieties currently grown in the region are very susceptible to leaf rust. Consequently, there has been no major selective pressure for new races of leaf rust. Races of *Puccinia graminis*, the pathogen causing stem rust, were numerous and uniquely different from races in other regions of the United States. The characteristics of the races and their diversity is evidence that the new races originated from barberry plants.

Effect of Weather. As in past years, the continual presence of living wheat plants throughout the year has provided adequate inoculum for the initiation of new stripe rust and leaf rust epidemics. When used in combination with monitoring data the model for predicting stripe rust proved to be reliable for the eighth consecutive year and when used with precipitation data enabled prediction of leaf and stem rust. Late fall planting, an unusually cold November and December, and less than normal precipitation in the spring prevented development of severe rust epidemics in 1986. More severe epidemics are expected in 1987 because of favorable weather in the fall and winter. The severity of the epidemics, however, would be reduced if the hot, dry weather in April and early May continues throughout the spring.

Resistance. High-temperature, adult-plant (HTAP) resistance to stripe rust, which has now been incorporated into all major soft white winter wheats and most spring wheats, has continued to be durable against all races in the Pacific Northwest; whereas, the high resistance that expressed in both seedling and adult plant stages at all temperatures has been effective for three years or less. Further information on the characteristics and inheritance of HTAP resistance in Gaines, Nugaines, and Luke (three varieties with different levels of resistance and different genes for resistance) has been obtained based on analysis of progeny from crosses of the varieties and crosses with a susceptible club wheat. The HTAP resistance which was transferred into the club wheat may be useful in developing club wheats with better stripe rust resistance.

Inheritance of slow rusting resistance to leaf rust in Borah and Wampum and a high type of leaf rust resistance in Wared was studied in crosses involving the resistant varieties and Twin, a highly susceptible variety. Borah, Wampum, and Wared each contain several genes for resistance to leaf rust, and the genes in each cultivar are different from those in the other cultivars. These genes should be useful in developing more durable leaf rust resistant wheats.

In 1986, more that 15,000 winter and spring wheats consisting of new germplasm commercial varieties, advanced breeding lines from breeders in the Pacific Northwest, and differential cultivars were evaluated for resistance to stripe rust and leaf rust and about 10,000 lines from the national germplasm collection were evaluated for seedling resistance to the four most virulent stripe rust races. The information on resistance of germplasm and advanced lines should provide breeders with new sources of resistance and should lead to an improvement in the resistance of wheat varieties in the future.

Use of Fungicides. Since 1981, Bayleton has been used to control stripe rust and leaf rust in the Pacific Northwest when existing varieties become susceptible to new races and in combination with various types of resistance. Guidelines for the use of Bayleton have been developed based on type of rust, type of resistance, intensity of rust, stage of growth, potential yield, and economic return. New fungicides which show greatest promise as foliar applications for control of stripe rust, leaf rust and stem rust are Folicur and Summit developed by Mobay, Tilt developed by Ciba Geigy, and Spotless developed by Chevron. Baytan developed by Mobay has potential as a seed treatment for control of stripe rust and leaf rust early in the season, but it must be managed carefully, because it can delay emergence under some conditions.

TAKE-ALL

R. J. Cook, D. M. Weller, and E. N. Bassett

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

The best control for take-all is crop rotation, i.e. do not grow wheat or barley in the same field more than once every two years where tillage is used and possibly every third year if no-till is used. Potatoes, alfalfa, corn, beans, peas, and lentils are all nonhost crops and break the take-all cycle. Irrigation water supplied in large but infrequent applications e.g., 3-4 inches every 7-10 days (as is possible with rill or solid-set systems) will also help keep take-all in check. Pivot irrigation is more favorable to the fungus. Thorough tillage helps control the disease by accelerating the death rate of the fungus. Tillage is an option for take-all control only if a rotation is not followed; but the best option is crop rotation. In fact, results of experimental trials make it abundantly clear that take-all control presently is not possible in consecutive crops of irrigated wheat without tillage. A major objective of our research is to control take-all without crop rotation, under pivots, and with less tillage. Good phosphorus fertility can give some control. The disease eventually declines with prolonged recropping (take-all decline), because of a natural biological control, but this control is ineffective if no tillage is used. We are attempting to develop a biological control whereby antagonistic root-colonizing bacteria (obtained from soils where take-all has declined) are applied as a living seed treatment. Yield increases of 10-25 percent are obtained about one-half of the time by use of these bacteria where take-all is the main yield-limiting factor. These bacteria currently are under test at Lind (irrigated wheat) and Mt. Vernon, WA (high rainfall area). There is commercial interest in development of a biocontrol product with one or more of our bacterial strains.

PYTHIUM ROOT ROT

R. J. Cook J. W. Sitton and J. A. Hauser

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

Yields of wheat in the high-production, annually cropped areas of eastern Washington would be 10-20 and sometimes 30-40 bu/A greater with the same water and current rates of fertilizer if *Pythium* could be controlled completely. The disease occurs to a remarkably uniform degree in wheat and barley fields of eastern Washington. *Pythium* is more active when straw and chaff are left on the soil surface (as with no-till), or blended with the top few inches of soil (as with minimum till); it uses nutrients from straw and chaff as a food source, and the fungus is favored as a pathogen by the cool, wet soil conditions typical of late sowings and soil with surface residues. The fungus is also more damaging on old (3-5 yr) than current-year seed.

Work on *Pythium* control involves a search for a chemical or biological seed treatment. Apron is the only effective seed-treatment chemical found to date, but even this chemical is inadequate to control the root rot phase of this disease. The only field treatment effective at present against root infections is fumigation of the soil with chloropicrin or Telone C17. On a broadcast/incorporation basis, the minimum effective treatment is about 15 gal of chloropicrin per acre or 25 gal of Telone C17 per acre. These rates are uneconomical. Some preliminary results indicate that significant *Pythium* control and yield increases are possible with about 1 gal chloropicrin/A injected below and to one side of the seed with the fertilizer at the time of sowing. These experiments using deep-band fumigation are continuing with metham sodium, which is less expensive.

The best control at present for Pythium root rot on winter wheat is to seed relatively early, e.g. mid to late September in areas with 18-20 inches of precipitation annually. Seeding this early is relatively safe if the field is in a three-year rotation but is risky if the field is in a two-year rotation (because of Cephalosporium stripe). If wheat must be sown late, e.g. early- to mid-October in areas with 18-20 inches of precipitation annually, it is best to use current year seed. Our best responses to Apron seed treatment have been with wheat seeded without prior tillage (no-till) into wheat or barley stubble in the high-rainfall area.

RHIZOCTONIA ROOT ROT

R. J. Cook, D. M. Weller, and E. N. Bassett

Rhizoctonia root rot was found in the U.S. for the first time in 1984, in six different fields of wheat or barley in the Pacific Northwest. At least two species of Rhizoctonia are responsible for the disease, and studies are now underway to determine which of the two (or other species) are most important in different regions of the Northwest. In greenhouse studies, peas, lentils and rape were also attacked by one of the two species, which may account for why crop rotation is ineffective as a control for this disease. Under field conditions spring barley is affected by this disease more severely than any other crop grown in the dryland Inland Northwest.

Rhizoctonia root rot is favored by no-till. Virtually any amount of tillage to disturb the fungus will result in less disease. In 1986, several fields of spring barley showed large patches of stunted plants caused by Rhizoctonia root. The disease was most severe in fields that had been reseeded to spring barley following winter kill of the barley or wheat sown the previous fall. Possibly the few surviving winter wheat or winter barley plants harbored the fungus, which then used the roots of these host plants as a springboard and foodbase to attack the newly sown spring barley.

Our field research on this disease is carried out at Lind on the station and is aimed at finding an effective seed-treatment chemical.

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

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

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

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

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

Quality tests for resistance to seed bleaching and for adaptability to reconstitution and canning are also conducted. New methods have been developed to accurately measure traits which influence resistance to pea seed bleaching, dark green color, and good color retention. These methods will improve efficiency of breeding efforts.

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

Varieties of peas developed are as follows:

'Alaska 81' was released to growers in 1984. The cultivar is early to flower (10th node), early to mature, and has excellent seed quality traits including dark green color and resistance to seed bleaching.

Alaska 81 has resistance to Fusarium wilt race 1 and is tolerant to pea root rot. Alaska 81 is immune to pea seedborne mosaic virus.

'Garfield' is resistant to Fusarium wilt race 1, is larger seeded, and has a longer vine habit when compared with most Alaska strains. The increased plant height improves harvesting ease, especially on ridges where poor vine growth has been a problem. Garfield does not differ from Alaska in resistance to seed bleaching, powdery mildew, or mechanical damage resistance. Garfield flowers at the 14th node and has tolerance to pea root rot, two factors which delay maturity about one week when compared with most Alaska strains.

'Tracer' is a small-sieve Alaska type that has yielded nearly 45% more than other small-sieve types. Other major improvements of Tracer over common, small-sieve Alaska strains include more uniform seed size, shape, and color; greater plant height; a lower susceptibility to seed bleaching; and resistance to Fusarium wilt race 1. The increased height of Tracer improves harvesting ease on the ridges where poor vine growth has been a problem. Tracer tends to set triple pods at one or more of the reproductive nodes.

'Umatilla' (WA910431). This line originated as an F_6 selection of a cross (XB75G027) between JI 34, a breeding line from the John Innes Institute in Norwich, England, and WA110-42, a selection from PI244251. Umatilla was yield tested at several sites in eastern Washington and northern Idaho from 1982 to 1985.

When compared with Latah, Umatilla is about 15 cm shorter (87 cm vs. 102 for Latah) and 13% higher yielding. Umatilla has a double podding habit compared to the single podding habit for Latah. The seeds of Umatilla are larger than Latah and have averaged 18.7 grams per 100 seeds compared to 17.1 for Latah. Seeds of Umatilla are bright yellow and represent a significant improvement in seed quality when compared to Latah in which the seeds have an undesirable green cast.

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

Varieties of lentils developed are as follows:

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

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

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

'Emerald' (selection 504). A bright green lentil with distinctively green cotyledons, has performed well over the past four years and is being proposed for release. Emerald would be a specialty type lentil because of its distinctive green cotyledon color.

Chickpeas: (Garbanzos) are grown throughout the world in similar environments to those where lentils are grown. The Palouse environment seems well suited to chickpeas and, based on 1980-84 results, very favorable yields can be obtained. Varieties and breeding lines have been obtained from sources both national and international and have been evaluated for yield potential and seed quality. Cultural practices which include: (1) seeding rates-row spacing, (2) seed treatments, and (3) *Rhizobium* inoculation have been completed. All indications are that chickpeas can be developed as a successful crop for the Palouse. There are basically two types of chickpeas: the "Kabulis", with large cream-colored seeds and the "Desis", with smaller seeds that are variously pigmented. Kabulis represent less than 20% of the world's production of chickpeas; the remainder are Desi types. The Desis are grown primarily on the Indian subcontinent and parts of Ethiopia; whereas, the Kabulis are grown primarily in the Mediterranean basin and North and South America. Less than 20% of the chickpea production in India, estimated at 22 million acres, are Kabuli types. Promising Kabuli lines being tested include the unifoliate types (CP-8, Surutato 77) and the more common types (U-5 and ILC517). Promising Desi varieties include C235, ICCC 4, and PI273879. Desi types appear to be well adapted to the Palouse environment and they appear to be easier to produce when compared to Kabuli types. Desis are also earlier to mature.

No chickpea trials were conducted in 1985; however, based on data collected from 1981-84, two lines are being proposed for release as follows:

'Tammany' (CP8). This selection has a unifoliate leaf structure which differs from the fern leaf structure that is typical of most chickpea cultivars currently in use. Tammany is earlier to mature and has larger seeds when compared to "UC-5"; the commonly grown cultivar in the region. Seeds of Tammany average 58 grams per 100 seeds compared to 52 grams from UC-5. The uniformly large light cream-colored seeds of Tammany are highly desired by domestic processors and by exporters.

'Garnet' (PI273879). This line originated as a plant introduction from Ethiopia and was mass selected for uniformity. Garnet has produced yields that were equal to or better than other Desi lines included in tests from 1982-84. Garnet matures in about 110 days from planting. The seeds are reddish-tan, uniform in size, and weight 16.4 grams per 100 seeds.

DROUGHT TOLERANT GRASSES AND LEGUMES FOR LONG TERM GROUND COVER IN WASHINGTON

C. A. Kelly, Manager
Pullman Plant Materials Center
Soil Conservation Service-USDA

Variety	Common Name	Scientific Name	Origin	MAP* (in.)
Nordan	Crested wheatgrass	*Agropyron desertorum*	USSR	8-10
Greenar	Intermediate wheatgrass	*Agropyron intermedium*	USSR	14-16
Sodar	Steambank wheatgrass	*Agropyron riparium*	Grant Cty, OR	12-14[1]
P-27	Siberian wheatgrass	*Agropyron sibiricum*	USSR	8-10
Secar	Bluebunch wheatgrass	*Agropyron spicatum*	Lewiston, ID	8-10
Whitmar	Beardless wheatgrass	*Agropyron spicatum inerme*	Colton, WA	8-10
Luna	Pubescent wheatgrass	*Agropyron trichophorum*	USSR	12-14[1]
Topar	Pubescent wheatgrass	*Agropyron trichophorum*	USSR	12-14[1]
Covar	Sheep fescue	*Festuca ovina*	Turkey	8-10
Ladak	Alfalfa	*Medicago sativa*	India	10-12
Sherman	Big Bluegrass	*Poa ampla*	Sherman Cty, OR	8-10
Canbar[2]	Canby bluegrass	*Poa canbyi*	Blue Mtns., WA	8-10[3]

*Approximate Mean Annual Precipitation required.

[1]At elevations above 3,500' may survive in less than 12" MAP.
[2]For use only in mixtures as an understory species.
[3]May require less precipitation on course-textured soil sites due to decreased vegetative competition.

CONTRIBUTORS IN SUPPORT OF RESEARCH
1986-87
ACKNOWLEDGMENT

The cereal research programs in Washington funded by state and federal appropriations are substantial, but would be significantly lower if it were not for the excellent support of the wheat, pea and lentil growers, as contributed through the assessment program. In addition, we are most grateful for the support of individual growers who furnish plot land and service, and the firms, who contribute through grants and products:

Fertilizer, Seed and Amendments

Agri Service Inc.
BNP Lentil Co.
Cenex
Chevron
Cominco American Inc.
McGregor Co.
Puregro
Rogers Bros. Seed Co.
J. R. Simplot
Tennessee Valley Authority
Unocal
Whitman County Growers
Wilbur Ellis

Herbicides

American Cyanamide
American Hoechst Corp.
Arcadian Corp.
BASF
BK-Ladenburg Corp.
Chevron
CIBA-Geigy
Diamond Shamrock
Dow
E. I. Du Pont de Nemours
Elanco Products Co.
F. M. C. Corp.
Hoechst-Roussell Agri. Vet
ICI
Intermountain Grass Growers Association
Mobay
Monsanto
PPG
Pennwalt Corp.
Rhone-Poulenc Inc.
Rohm & Hass
Russ Smith-Lind Air Service
Shell
Smith & Ardussi
Stauffer Chemical Co.
TH Ag. & Nutrition Co., Inc.
Union Carbide Ag. Products Co.
Sandoz Crop Protection Corp.
Wash. Wheat Commission
Wilbur-Ellis Co.
Zoecon Corp.
Vertac Chem Corp.

Cash Contributions

Agripro
Amer. Cyanamid Co.
Amer. Malting Barley Asso.
Arcadian Co.
BASF Wyondotte Corp.
Chevron
Dow Chemical Co.
E. I. Dupont de Nemours
Elanco
Grant County Crop Improve. Association
Great Western Malting Barley
Gustafson
Norm Heistuman
Hoechst-Roussel Agri-Vet Co.
Intermountain Grass Growers Association
ICI
Leffingwell
Mobay Chemical Corp.
Monsanto
Northwest Plant Food Assoc.
O. A. Vogel Fund
Pacific Northwest Grain Council
Potash-Phosphate Institute
PBG Industries, Inc.
Rhone-Poulenc Inc.
Rohm & Haas Co.
Stauffer Chemical Co.
Sandoz Crop Protection Corp.
Trans Agra Corp.
Union Carbide
Washington Barley Commission
Washington Wheat Commission
Wash. Dry Pea & Lentil Commission
Wilbur-Ellis Co.

Farmer Cooperators

Edison Appleford	Anatone
Lynn Ausman	Asotin
Dale Bauermeister	Connell
Joe Babbit	Pullman
Bayne Farms	Horse Heaven
Wayne Beale	Pomeroy
Bud Benedict	Asotin
Ken Berry	Endicott
Kurt Blume	Genessee, ID
Ray Brandon	LaCrosse
Malcolm Brown	Garfield
Albert/Doug/Dan Bruce	Farmington
Ralph Camp	LaCrosse
Ed Chratal	Touchet
Girard Clark	Pullman
Jim Cochran	Palouse
Louis Cosner	Goldendale
Don Crisp	Pullman
Earl Crowe	Farmington
Richard Daily	Palouse
Rick Dean	Grangeville, ID
Van Deffenbaugh	Kennewick
Dale Dietrich/Wilke Farm	Davenport
Dan Doty	Colfax
Drew Druffel	Colton
Bob Druffel	Uniontown
Roger Dye	Pomeroy
James/Frank Ferrel	Walla Walla
Foundation Farms	Waitsburg
Bob Frazier	Walla Walla
Les Guske	LaCrosse
Dan Harwood	St. John
Bob Heitstuman	Colton
Norman Heitstuman	Uniontown
Curt Hennings	Endicott
Vince Hensel	Palouse
Ed and Henry Hiller	Pomeroy
Hoffman Farms	Clyde
Lowell Huffman	Lenore, ID
Cleater Hughes	Endicott
Tom Hyslop	Espanola
Albert Jacobson	Waterville
Chet Johns	Rockford
Larry Johnson	Mt. Vernon
Dwelly Jones	Walla Walla
Dick Juris	Dayton
Ron Juris	Bickleton
Rick Kamerrer	Pullman
Charles Keno	Fairfield
Sean Kinzer	Pullman
Koller Farms	Mayview(Pomeroy)
Oscar Kranzler	Ritzville
Robert Kramer	Harrington
Jerry Krause	Creston
Dick Kriebel	Garfield
Quenin Landreth	Espanola(Deep Creek)
Harvey Lehmitz	Endicott
Steve Mader	Pullman
Jerry Maley	LaCrosse
Bob and Brad Marlow	Rockford
Pat and Don Meiner	Walla Walla
Bob McKiernan	Pullman
McGregor Farms	Hooper
Mielke Farms	Harrington
Bud Mills	Tensed, ID
Mac Mills	St. Johns
Don and Steve Moore	Dusty
Tedd Nealy	Endicott
John Ochs	Dusty
Donald Ogle	Waterville
Gary Osborne	Troy, ID
Don Quist	Palouse
Allen Redman	Palouse
John Robinson	Pomeroy
Luther Roecks	Fairfield
Harold Schultheis	Colton
John Schlomer	Winona
Tom Schultz	Reardan
Harvey Schumacher	Lewiston, ID
Jim Scott	Pomeroy
Dave Scott	Spokane
John and Greg Slomer	LaCrosse
Darell Storment	Endicott
Elmo and Larry Tanneberg	Coulee City
Merle and Bob Thiessen	Lewiston, ID
Tig Ranch	Land, WA
Maurice Ulhorn	Ferdinand, ID
Tony Viebrock	Waterville
Bob Walli	Ralston
Don and John Wellsandt	Ritzville
Curt White	Lamont
Paul Williams	Reardan
Jon Whitman	Pullman
Mike Whitman	Pullman
Joe Wolf	Clarkston

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

Adams Co. Wheat Growers
Agri-Service Inc.
American Malting Barley
Lind Grange
McGregor Company
Palouse Conservation District
Palouse-Rock Lake Conservation District
Whitman Conservation District
Whitman Co. Wheat Growers
Wilfac
Yielder Drill Inc.

COOPERATIVE PERSONNEL AND AREA OF ACTIVITY

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L. F. Rogers...........................Director of Resident Instruction
J. J. Zuiches..Director of Research, College of Agriculture & Home Econ.
J. C. Engibous.................Interim Director of Cooperative Extension
H. H. Cheng.......................Interim Chairman of Agronomy and Soils

Cereal Breeding, Genetics, and Physiology

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K. J. Morrison, P. E. Reisenauer, Pullman...............Varietal Testing
M. K. Walker-Simmons, J. Sesing-Lenz..................Cereal Physiology

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

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H. C. Jeffers.....................................Research Technologist
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G.E. King.....................................Early Generation Testing

Cereal Diseases

S.D. Wyatt, Tim Murray......Cereal Viruses, Foot Rots and Other Diseases
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R. F. Line, Cooperative USDA..........................Flag Smut Control

Breeding and Culture of Dry Peas and Lentils

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Weed Control

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

Dry Pea Production, EB0582
Growing Lentils in Washington, EB0590
Garfield and Tracer Alaska Type Peas, EB0699
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Andre Spring Barley, EB1249
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