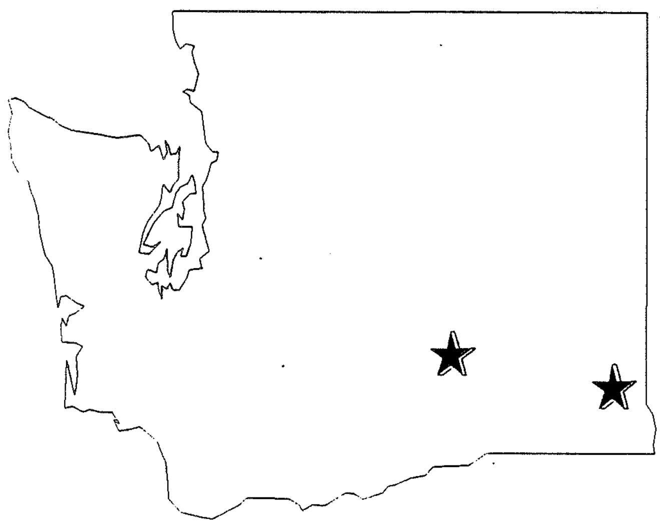
WASHINGTON STATE UNIVERSITY



FIELD DAYS

June 23, 1988

Dry Land Research Unit, Lind

June 30, 1988

Palouse Conservation Station Field Day, Pullman

July 7, 1988

Spillman Farm, Pullman

TABLE OF CONTENTS

DEDICATION

Dr. Kenneth (Kenny) Morrison accepted the position as Extension Agronomist at Washington State University in 1950. He held this important assignment for 37 years, retiring July 31, 1987. During this time he was solely responsible for direction and coordination of extension activities of all major field crops grown in Washington, including small grains, forages, oil seed crops, pulses, grass and legume seed. The complexity of this assignment is enhanced by the wide diversity of agro-ecosystems found in the state. Kenny had expert knowledge of all of these various growing regions, management and economic systems.


Kenny Morrison

Dr. Morrison possessed the needed abilities of an outstanding extension agronomist. Kenny could quickly grasp the importance of crop research and transform it into information readily assimilated by growers. He welcomed his role as liaison among producers, processors and researchers. Dr. Morrison deserves major credit for the excellent rapport which exists between scientists, growers and others of the agricultural industry. In turn, researchers have obtained special insight into numerous grower and processor problems through him. His integrity and reputation as an untiring worker had gained him the respect of the entire agricultural industry.

Extending research findings was Dr. Morrison's greatest achievement. Each year he organized informal field tours which allowed for direct interaction of growers and researchers. He developed and presented TV programs on a variety of timely subjects, including stand establishments, sprout-damaged wheat, smut quarantined grain, seed quality, pros and cons of seed treatment, lawn management and value of high quality seed. Kenny was a master of using on-farm demonstrations to convince growers to use adapted cultivars, high quality seed, recommended management practices, and proper use of pesticides. In the past 37 years he had conducted over 35 workshops on a diversity of subjects including small grain production, turf grass management, irrigation practices, seed production, range management, land appraisal and grain marketing. Kenny closely supervised the sessions, making sure the participants understood the information and that the objectives of the workshop were fulfilled.

Dr. Morrison had served as a member of the Board of Directors of the Washington State Crop Improvement Association (WSCIA) over 30 years. Under his guidance WSCIA has steadily grown and now is one of the nation's leading crop improvement organizations.

In addition to his professional activities, Dr. Morrison found time to participate in a wide range of civic and service club activities. He was President of the Pullman Rotary Club in 1976-77. He was a member of the Farmhouse Fraternity, Pullman Chamber of Commerce, the El Katif Shrine of Spokane, and the Masonic Lodge. At the time of his death (October 14, 1987), Dr. Morrison was Governor-Elect for District 508 of Rotary International.

Comments From Dwane G. Miller

Welcome to our field days, we hope you enjoy the tours as well as the material presented in this booklet. I had the privilege of being named chair of the Department of Agronomy and Soils in the College of Agriculture and Home Economics at Washington State University on September 7, 1987. It is a pleasure to be back at WSU after having served earlier on the Agronomy and Soils faculty from 1967 - 77. After leaving in 1977, I served on the faculty at Texas Tech University, and as Department Head of the Plant and Soil Sciences department at Montana State University since 1981. I look forward to my new rôle in working with the departmental faculty in bringing our research, teaching, and extension functions to the public.

My research involved chemical induction of male sterility in wheat as related to hybrid wheat production at Washington. I also conducted research in the production of peas and lentils. My teaching involvement was mainly with undergraduate courses. I completed my Ph.D. from the University of Wyoming in 1966 in Crop Science and am married with a family of three daughters. My wife Shirley and youngest daughter moved to Pullman in October where we are building a new home.

The Agronomy and Soils department is primarily concerned with agronomic crop production and the wise use of our soil resources. Plant breeding, weed control, end-product quality, soil properties, plant nutrition, soil biology, water quality and land use are a few areas of major concern to our department. In these areas we are Washington-oriented but our endeavors have regional, national, and international reaches as well. We take our "Land Grant" responsibilities and "Scientific" roles seriously. Thus, our mission is both applied and basic. Our goal is to be successful in our mission and the activity in this booklet is a step in that direction.

After that brief introduction, I hope you will take the time to stop by my office or give me a call (509-335-3475). Let us hear from you. We hope you will learn something from these field days and appreciate your support for programs of this type.

Have a good day.

PERSONAL INTRODUCTION FROM BAIRD C. MILLER

I come to Washington with the enthusiasm and experience to meet the challenge this region offers an Extension Agronomist.

My educational career has included completing a Bachelor's degree in Plant Science-Agronomy at the University of California-Davis in 1980; a Master's degree in Agronomy at the University of Wisconsin, Madison in 1982; and finally a Ph.D. in Plant Physiology at the University of California-Davis in 1988. My interest and Active participation in Extension activities started during my employment with county agents as an undergraduate. I chose a graduate educational and research program to further challenge my interest and prepare for a career in Cooperative Extension. Having worked under the direction of Statewide Agronomy Extension Specialists Dr. E. S. Oplinger and Dr. J. E. Hill, I come with firsthand knowledge and experience of the pivotal role I will have in addressing the practical needs of our producers and the agricultural industry.

My field studies as a graduate student focused on practical management-oriented problems including: establishment of sunflower as an alternative cash crop; cultural and plant growth regulator trials with wheat, field beans, corn, soybeans, sunflowers, and alfalfa seed production. In addition, I actively participated in the statewide variety evaluation programs for each of these crops. The objective of my recently completed Ph.D. thesis was to develop a rice crop growth program for use in the scheduling of management actions and integration of pest management strategies, based on the phenological and morphological development of the rice crop in California.

As part of my Extension responsibilities I will continue the leadership role and work toward strengthening the statewide small grains variety evaluation program. This variety evaluation program serves several significant purposes. The program provides a continuously expanding information database for the comparison of varietal performance based on yield, disease and pest resistance, stand establishment and winterhardiness across a wide range of climatic and soil conditions. This information is essential in assisting producers in their varietal selection task, as well as assisting the breeders in evaluating selections as new variety releases. These trials serve as fertile ground for observing differential varietal performance, and the dissemination of new management information developed by university researchers and the agricultural industry. Finally, from a personal perspective I envision these studies as an invaluable opportunity to interact with our producers, establishing a level of communication that will keep our Extension and research efforts in the state focused on the needs of the industry.

Additional Extension activities will include technical support for county agents, participation in grower meetings, development of production manuals, distribution of newsletters for current interest and late-breaking news, participating as a university representative in industry organizations, as well as a spokesman for producers in identifying the direction and needs of university research.

My crop management research will take a "systems" approach, accounting for the interacting components of the agricultural system. Computer applications provide a powerful technique in an integrative approach to management problem-solding. Expert systems development would be useful in supporting the management and on-farm decision-making process, for example: variety selection based on local adaptability, disease and pest resistance and current market trends; fertilizer applications based on current soil analysis, weather patterns, cropping history and economics; choice of alternate or cover crops based on current market status and farm program policies. My research interests also include: (1) development of alternate cropping system strategies to minimize soil erosion potential and achieve compliance with the farm conservation program; (2) the influence of the "manageable environment" on crop development or phenology, variety adaptation and grain yield stability. My philosophy and problem-solving approach clearly necessitates a cooperative and interdisciplinary research effort. Washington State University, as well as this tri-state region, have an impressive, proven track record of the type of cooperative research effort necessary for serving the needs of our producers. I look forward to being an active member of this team.

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 seventy-second field day. Visitors are welcome at any time and their suggestions are appreciated.

HISTORY OF SPILLMAN FARM

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

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

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

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

Ray Nelson was appointed farm manager in July 1981.

CLIMATIC DATA

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

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

Month	Temperature °F.		Precipitation		Precipitation
	Max.	Min.	1987	1988	67 yrs. Av (in)
January	34	22	.97	.43	1.02
February	42	24	.19	.01	.88
March	53	32	1.03	1.09	.79
April	63	35	.54	1.57	.66
May	72	42	.84		.78
June	83	45	.34		.83
July	90	52	.75		.25
August	90	50	.37		.33
September	79	45	.01		.57
October	65	38	T		.85
November	47	29	.82		1.22
December	37	26	2.24		1.29
			8.10		9.47

Climatic measurements are made daily with standard U.S. Weather Bureau instruments. Data recorded are maximum and minimum temperature, daily precipitation, relative humidity, daily wind movement, and daily evaporation. In addition, automatic instruments make a continuous record of soil and air temperatures and precipitation.

Table 2. Temperature and precipitation at Palouse Conservation Field Station, Pullman, 1987-88

Month	Monthly Avg. Temperature(F) Max.	Min.	Precipitation (in) 30-Yr. Avg.*	Monthly	Total Accum.	Deviation from Avg. Monthly	Accum.
1987							
January	34.0	22.7	2.87	1.90	1.90	- .97	- .97
February	44.5	30.9	2.31	1.40	3.30	- .91	-1.88
March	51.7	34.1	2.09	1.79	5.09	- .30	-2.18
April	65.1	38.9	1.56	1.03	6.12	- .53	-2.71
May	69.7	43.5	1.58	2.23	8.35	+ .65	-2.06
June	78.0	48.5	1.56	1.57	9.92	+ .01	-2.05
July	79.2	51.2	.64	1.59	11.51	+ .95	-1.10
August	82.7	48.5	.92	.18	11.69	- .34	-1.84
September	80.6	43.5	1.03	.00	11.69	-1.03	-2.87
October	68.6	34.3	1.71	.00	11.69	-1.71	-4.58
November	47.4	32.9	2.79	1.22	12.91	-1.57	-6.15
December	34.6	23.5	3.13	2.98	15.89	- .15	-6.30
TOTAL	61.4	37.8	22.19		15.89		-6.39
1988							
January	34.6	22.9	2.87	2.15	2.15	- .72	- .72
February	47.4	26.0	2.31	.89	3.04	-1.42	-2.14
March	48.3	30.8	2.09	2.56	5.60	+ .47	-1.67
April	59.5	38.2	1.56	2.00	7.60	+ .44	-1.23
TOTAL			8.83		7.60		-1.23
1987 CROP YEAR Sept. 1986 thru June 30, 1987			20.63		17.01		-3.62

* Thirty-eight year average for precipitation, 1948 - 1985

ADAPTED PUBLIC VARIETIES - WHEAT, OATS, BARLEY

AREA	WINTER WHEAT	SPRING WHEAT	OATS	SPRING BARLEY	WINTER BARLEY
EASTERN WASHINGTON					
14 Inches or More Rainfall	Daws Stephens Tres Hill 81 Lewjain Crew Dusty Hyak Madsen	Dirkwin Waverly Edwall Owens Penawawa	Cayuse Appaloosa Monida	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 Hyak	Wampum Waverly Dirkwin Edwall Owens Penawawa McKay		Steptoe	Kamiak
CENTRAL WASHINGTON					
Under Irrigation	Daws Stephens Hill 81 Lewjain Dusty Madsen	Wampum Waverly Dirkwin Owens Penawawa McKay	Cayuse Appaloosa Monida	Andre Klages Steptoe Belford-hay only Cougbar	Boyer Hesk Showin
Snow Mold Areas	Sprague John Andrews				

WHEAT, BARLEY AND OAT CULTIVARS

WINTER WHEAT

Daws

Daws is a soft white common semidwarf wheat. The variety has about a 5 percent yield advantage over Nugaines. It is more winterhardy than Nugaines but is not as hardy as Wanser or McCall. Daws has good milling property and the flour quality is satisfactory. The variety emerges slower than Nugaines. Daws has good stripe rust resistance but is susceptible to Cercosporella foot rot, snow mold, dwarf smut, and Cephalosporium stripe (fungus stripe). It is moderately susceptible to leaf rust. Daws was developed by USDA-ARS and Washington State University.

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 winter-hardiness, 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.

Hill 81

Hill 81 is a soft white common semidwarf winter wheat. It is mid-tall with white stiff straw. The spike is awned with white. It is more winterhardy than Stephens but is not as winterhardy as Daws. Hill 81 has seedling resistance to local races of stripe rust and common bunt. It has good adult plant resistance to the current races of stripe rust and leaf rust. It is susceptible to Cercosporella foot rot and moderately resistant to Cephalosporium stripe. Hill 81 has maintained high yields, being comparable to Daws but with less yield than Stephens when winter injury is not a factor in yield. The variety has promising overall white wheat quality characteristics with quality similar to Nugaines. Hill 81 was developed by Oregon 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.

Lewjain

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

Madsen

Madsen (WA007163) is a soft white winter wheat with resistance to strawbreaker foot rot. It will be released to the growers in the fall of 1988. Madsen is also resistant to the local races of stripe rust, leaf rust, and it has a good yield potential. It has a common-type head with white chaff. The milling and flour quality of Madsen is similar to that of Hill 81. Madsen was developed by ARS-USDA and WSU.

Sprague

Sprague is a soft white common wheat developed for the snow mold areas. The chaff varies white to gray-brown; the heads are small and awned. It has high tillering capacity from early seedlings but the straw is weak. The test weight of Sprague is below Nugaines but it has been above 60 pounds per bushel. Sprague has good resistance to snow mold and common bunt but is susceptible to dwarf bunt, stripe and leaf rusts, and *Cercosporella* foot rot. It has excellent emergence and good winterhardiness. Sprague was developed by USDA-ARS and Washington State University.

Stephens

Stephens is a soft white common wheat released at Oregon that is resistant to stripe rust and common smut. It is moderately resistant to *Cercosporella* foot rot. Stephens is susceptible to leaf rust, dwarf smut, flag smut, snow mold, and *Cephalosporium* stripe (fungus stripe). It is similar to Nugaines in emergence. The grain yields of Stephens are slightly higher than Nugaines, MdDermid, and Hyslop. Stephens has the same winterhardiness as Hyslop. The milling and flour qualities of Stephens are similar to that of Nugaines. Stephens was developed by Oregon State University.

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. Crew was developed by ARS-USDA and WSU.

Hyak

Hyak (WA007166) is a semidwarf soft white club winter wheat with resistance to strawbreaker foot rot. It will be released to the grain producers in 1988. Hyak is resistant to the local races of stripe rust, leaf rust, and Hyak has good yield potential. The milling and flour characteristics of Hyak are equal to those of other club varieties. Hyak was developed by ARS-USDA and WSU.

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.

Andrews

Andrews (WA6820) is a white-chaffed, semidwarf hard red winter variety. Andrews has good resistance to snowmold and fair resistance to dwarf bunt and stripe rust. It is susceptible to leaf rust and *Cercosporella* foot rot. Yield performance out of the snowmold area has been fair. Emergence is typical of a semidwarf. Andrews is somewhat low in flour yield when milled. The bread baking properties of the flour are satisfactory. Andrews was developed by WSU 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.

Weston

Weston is a hard red winter wheat variety with a brown-chaffed common head. The variety is taller and has weaker straw than Hatton or Wanser. Weston is susceptible to the races of stripe rust that attack Moro and most club wheats. It has some resistance to leaf rust and is resistant to local races of common and dwarf bunt. It has moderate snowmold resistance. Emergence is excellent. Flour protein tends to be slightly higher than Hatton or Wanser. Milling and baking properties are satisfactory. Grain yields of Weston are somewhat better than Wanser, but usually less than Hatton. Weston was developed by the University of Idaho.

SPRING WHEAT

Dirkwin

Dirkwin is a beardless, white-chaffed, semidwarf wheat released in 1978. It is a very widely adapted variety, yielding well under both droughty and high-producing conditions. Compared to Twin, Dirkwin is similar in plant height, test weight, and heading date. Dirkwin is resistant to powdery mildew, stem and stripe rust. However, Dirkwin is susceptible to prevalent races of leaf rust. The milling and baking qualities of Dirkwin are satisfactory. Dirkwin was developed by USDA-ARS and the Idaho Experiment Station at Aberdeen, Idaho.

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.

Owens

Owens is a semidwarf, awned, stiff-strawed soft white spring wheat developed by USDA-ARS at the Idaho branch experiment station at Aberdeen, Idaho. Owens carries the same resistance to stripe rust present in Dirkwin, but is susceptible to currently prevailing forms of leaf rust and mildew. Owens has high test weight and satisfactory milling and baking properties. Owens yields competitively with other soft white spring wheats when leaf rust is not severe. Seed supplies of Owens are yet somewhat limited. The variety was not released in Washington because of its greater susceptibility to leaf rust than Dirkwin and Waverly.

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.

Waverly

Waverly is a semidwarf, white-chaffed, soft white spring wheat developed by Washington State University and USDA-ARS. Waverly has good lodging resistance with considerable straw height for nonirrigated and irrigated spring wheat production. Waverly matures one to three days later than Fielder and about one to five days earlier than Urquie. Waverly is moderately resistant to stripe rust, leaf rust and stem rust. It is moderately susceptible to mildew. The test weight is slightly below Fielder and Urquie but superior to Twin and Dirkwin. The variety has about the same yield potential as Owens. The yields of Waverly are higher than Fielder when stripe and leaf rusts are present. Waverly carries adult plant resistance to stripe rust which becomes effective at a later growth stage than is the case for Urquie. The variety has good milling and baking quality when grown on nonirrigated or irrigated land.

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.

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.

WINTER BARLEY

Boyer

Boyer is a 6-row, white-kerneled, winter barley variety with rough awns but it does not have the severe "itching" characteristics of other winter varieties. The variety has a high yield record and relatively short, stiff straw with 15 percent less lodging than most other winter barleys. Boyer is slightly more winterhardy than other varieties except Kamiak. Boyer has shorter straw than most other winter barleys. The kernels of Boyer are larger and plumper than other winter barleys. Boyer was developed by Washington State University.

Hesk

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

Kamiak

Kamiak is a 6-row winter barley. It has produced high yields in tests. Kamiak has good winterhardiness. Kamiak is mid-tall and lodging can be a problem. The test weight of Kamiak is moderately high. The variety has early maturity. Kamiak does not have small glume hairs which cause "itching" during threshing. Kamiak performs well in eastern Washington. Kamiak was developed by Washington State University.

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.

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.

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.

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.

Klages

Klages is a 2-row malting barley adapted to production with irrigation. The variety is not well-adapted to low moisture dryland situations. Klages has stiff straw and the beards are rough. It is midseason in maturity. The variety has excellent malting quality but does not have as high yield record in Washington tests as other 2-row malting varieties. Klages was developed by the USDA and the University of Idaho.

Steptoe

Steptoe is a 6-row, rough-awned, spring nonmalting barley with a high yield record. The test weight is high for a 6-row. Steptoe heads later than most 6-row varieties. The variety has stiff straw with good lodging resistance. The straw is medium-tall. The heads are erect with rough awns. The variety is not acceptable for malting. Steptoe was developed by Washington State University.

OATS

Appaloosa

Appaloosa is a new yellow spring oat developed by Washington State University with more yellow dwarf virus tolerance than Cayuse. Appaloosa has up to 10 percent higher yield performance compared with Cayuse, but slightly lower average test weight. Appaloosa is a mid-season spring oat with straw 1 to 2 inches shorter than Cayuse. It has slightly better resistance to lodging than Cauyse.

Cayuse

Cayuse is a high-yielding, moderately early spring oat recommended in Washington. Cayuse was developed by Washington State University from a selection made at Cornell University. It is a short, pale green variety with open and spreading heads. The straw is strong and resistant to lodging. The kernels are light yellow. Cayuse has yielded 10 to 20 percent more than Park in test plantings. The main weakness of Cayuse is its low test weight compared with that of Park. The test weight of Cayuse has averaged about 35 pounds per bushel in all Washington locations, with 37 for Park. Cayuse has fair tolerance to the most serious oat disease in Washington--barley yellow dwarf virus disease, or "red leaf of oats". The yellow dwarf tolerance of Cayuse can be seen mainly in its high-yielding ability. Discoloration results after severe attack by aphids carrying the virus. No other disease of consequence has attacked Cayuse at any Washington location since testing began in 1959. Cayuse is susceptible to node blackening and stem break in the eastern part of the United States, but the disease does not affect oat yields in Washington.

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 near Lind and under irrigation at the Royal Slope experimental farm near Othello. Smaller scale research test plots are conducted via grower cooperation on the Dale Bauermeister farm near Connell (dry land summer fallow), at the Kramer ranch near Harrington (dry land recrop), near Pullman at the Don Quist Ranch (dryland, recrop) at the Jim Ferrel Farm near Walla Walla (dry land, recrop), and at the WSU Wilkie Research Farm near Davenport (recrop and management trial). Extension-related trials at numerous locations 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 several research test locations. The uniform yield trials include Washington State soft white and hard red spring wheat nurseries of up to 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. Since 1986 most off-station 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 (Quist ranch). This group of nurseries, plus crossing blocks with many introduced accessions, supplement the base of germplasm available for cross-breeding.

New Varieties

Descriptions of Edwall and Penawawa are presented elsewhere in this issue.

New Releases in 1988

Currently in Breeder, Foundation seed increase and distribution channels by WSCIA are three new spring wheats:

1. WA7183 (Wakanz) - Wakanz soft white spring wheat was developed by Washington State University with cooperation from USDA-ARS. Foundation seed was available for registered seed production in May 1988. Wakanz is the first soft white spring wheat cultivar developed for use in conservation tillage production situations where hessian fly damage can be a problem. Wakanz carries gene H_3 for resistance to the hessian fly. Wakanz has moderate to good resistance to the prevailing stripe leaf and stem rusts. Its stripe rust resistance appears to be of the adult plant type. Wakanz is among the highest yielding of cultivars developed by WSU to date. It has good lodging resistance. It is moderately susceptible to mildew.

2. WA7075 (Spillman) - Breeder and foundation seed of Spillman are in production in 1988. Production of quality breeder seed has been

slightly delayed due to the discovery of white seed contaminants, requiring intensive line increase and screening before bulking. Breeder and Foundation seed produced in 1988 should meet purity requirements.

3. WA7187 (Wadual) - Wadual is a unique new dual purpose processing quality soft white spring wheat developed by WSU with the cooperation of USDA-ARS. Wadual flour has capability for both leavened bread and pastry production based on extensive testing by the USDA-ARS Western Wheat Quality Laboratory, and cooperative baking trials by industry.

Wadual is the first soft white spring wheat cultivar developed with this capability. Line progeny analyses have shown that the dual processing traits are due to a genetic combination, not a mixture of genotypes.

Wadual combines these properties with good yield potential approximating that of Edwall and Waverly. It has moderate resistance to stripe leaf and stem rust and moderate susceptibility to mildew.

Wadual is expected to have a place for use in specialty products including whole wheat products, crackers and in applications replacing hard white wheats. Its unique and superior quality properties allow it to be blended freely in marketing and use channels while improving rather than deteriorating the quality of blends as would a hard white wheat.

4. Other lines - WA7492 and WA7176 continue to be evaluated to provide back-up for Wakanz. These lines have a somewhat higher type of stripe rust resistance than Wakanz and have equal yield-potential. Samples for possible breeder seed are being purified.

WA7496 - seed stocks of this higher quality high yield, SWS wheat are being purified.

WA7328 - seed stocks of this hessian fly resistant HRS wheat are being purified on the possibility for breeder seed production.

WA7326 - seed stocks of this HRS wheat are being purified. WA7326 yields equal to Spillman, and in some tests had a similar grain protein advantage. Its disease resistances are genetically different.

Advances in On-going Research

Spring wheat research at WSU is adapting to the changes coming about in cropping practices and the problems foreseen to accompany 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 differences in tolerance to *Fusarium* dry land foot rot. Consequently, a shift was made to grow the WSU State HRS and SWS nurseries at the critical moisture limiting recrop sites near Harrington, Davenport and Pullman to gain better data on variety and genotype performance under anticipated moisture stress conditions. In addition, as funds permit 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 has been placed on the improvement of quality traits in a new cycle of breeding for disease and pest resistance and improved yield. Sources of germ plasm for improved noodle quality have also been included in new crosses, and rapid screening for noodle quality is being investigated. The advances made in qualtiy improvement are due in large measure 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. New stripe rust races have appeared in New Zealand, permitting us to select for broader based resistance complementary to our adult plant resistance.

New Technology

Anther culture - A new biotechnology technique permitting the rapid production (within months) of true breeding lines from crosses has been initiated and already is in a high state of development at WSU. This technology will complement other methods, possibly displacing some in the long run. But most important, the method could greatly expedite variety development at WSU, if adequate financial support can be achieved.

We already have identified wheats that have excellent culturability traits. However, several recent WSU soft white wheats produce good yields of embryoids from culture, but regeneration into plants results in a high proportion that are albino (lethals), whereas other accessions (especially HRS types) may produce over 90% green plantlets upon regeneration in culture. These differences are genetically controlled. We must therefore screen our germ plasm base for culturability in the process of developing the anther culture system for practical applications.

Soft White Spring Wheats

WSU's "shuttle breeding" program already has been influential on the release of SWS wheats, Edwall and Penawawa (Tables 1-4), 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. Wakanz was developed from the early phase of this hessian fly resistance breeding program and has been released 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. New selections from Dr. Pike's screening were increased in New Zealand in 1987-88. Sister selections WA7492 and WA7176 have a similar yield but better stripe rust resistance. These are being advanced as a backup (see Tables 1,3,4).

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. Selections from crosses among these lines and sources of higher protein and of other semidwarfing genes are already in yield lots, and are being evaluated for hessian fly resistance. Yields in 1987 suggest these new lines may be far superior to their parents. The most advanced lines 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 2,3,5) 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 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 Registered 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 1988, as ample seed supplies are available, and its disease resistance remains adequate. It will gradually be replaced by Penawawa which produces grain of higher test weight, and which carries higher resistances to stripe rust, wider adaptability and has a better yield performance record. Landmark and Discovery are two privately developed soft white cultivars. Others are hard red spring types developed largely for the northern Great Plains region. Entries included come from 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 1988 release Spillman should replace most of the Wampum when certified seed is available. New entries have not been evaluated sufficiently for comment (see Tables 3,5).

Locations and Management of Evaluation Trials

With the development of the new WSU spring wheat cone planter cooperatively with the WSU Department 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 (6") 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, Walla Walla and near 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. Dry starter fertilizer 10N, 13P, 9S is placed with the seed at planting. 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

CHARACTERISTICS OF SOFT WHITE SPRING WHEATS

Name	Origin	Height	Maturity	Awns	Quality rating	Drought tolerance	Dryland foot rot	Stripe rust Reaction	Stripe rust Type	Leaf rust	Stem rust	Mildew	Hessian fly	Irrig.	Adaptation High rain	Adaptation Low rain	Recrop
	(1)	(2)	(3)		(4)	(5)	(5)	(5)	(6)	(5)	(5)	(5)	(5)				
Bliss	USDA-ID	SD	L	Y	S	VS	S	MR	AD	S	R	S	S	Y	N	N	N
Dirkwin	USDA-ID	SD	EM	N	S-	MS	S	R	SP	S	R	S	S	Y	Y	Y/N	?
Edwall	WSU	SD	M	Y	S	MS-MR	MS	R-MR	AD+SP	R-MR	R	S	S	Y	Y	Y	Y
Landmark	FL-ML	SD	M	Y	E	?	?	R	AD+SP	R	R	R	S	Y	Y	Y	?
Owens	USDA-ID	SD	M	Y	E	S-MS	S-MS	R	SP	S	R	S	S	Y	Y	?	?
Penawawa	WSU	SD	M	Y	S	MS-MR	MS	R-MR	AD+SP	R-MR	R	S	S	Y	Y	Y	Y
Wakanz(new)	WSU	SD	M+	Y	S	MS-MR	MS	MR	AD+	R-MR	R	S	R	Y	Y	Y	Y
ID232	USDA-ID	SD	M	Y	E	?	?	R	SP	R	R	R	R	Y	Y	Y	Y
WS1	WS	SD	M	Y	S-	S	?	MR	AD+	MR	S	?	S	Y	Y	N	N
Waverly	WSU	SD	M	Y	S	MS	S	MR	AD	MR	MR	S	S	Y	Y	Y	Y
Treasure	USDA-ID	SD	M	Y	S	?	?	R	SP?	MR?	R	S	S	Y	Y	?	?

TABLE 2

CHARACTERISTICS OF HARD RED SPRING WHEATS

Name	Origin	Height	Maturity	Awns	Protein	Drought tolerance	Dryland foot rot	Stripe rust Reaction	Stripe rust Type	Leaf rust	Stem rust	Mildew	Hessian fly	Irrig.	Adaptation High rain	Adaptation Low rain	Recrop
	(1)	(2)	(3)			(5)	(5)	(5)	(6)	(5)	(5)	(5)	(5)				
Bronze Chief	GPS-MT	SD	M	Y	Y	?	?	S	?	S	R	R	S	Y	Y	?	?
Buck Mapuche(new)	CENEX	SD	EM	Y	Y	?	?	MR	?	R	R	?	S	Y	Y	Y	Y
Ceres	FL-ML	TSD	EM	Y	Y	?	?	MR	AD+SP?	R	R	R	S	Y	Y	Y	Y
Copper(new)	USAD-ID	SD	M	Y	?	?	?	R	AD+SP?	S	R	R	S	Y	Y	Y	Y
Kodiak	GPS-MT	SSD	M	Y	N	?	?	MS	AD	?	S	S	S	Y	Y	N	N
McKay	USDA-ID	SD	M	Y	?	?	?	R	AD+SP	R	R	R	S	Y	Y	Y	Y
NK751	NK	SD	EM	Y	N	?	?	R	AD+SP	R	R	R	S	Y	Y	?	?
Nordic(new)	Agripro	SD	LM	Y	N	?	?	MS	?	?	?	?	S	Y	Y	Y	?
Spillman(new)	WSU	SD	M	Y	Y	?	?	R	AD+SP	R	R	R	S	Y	Y	Y	Y
Tammy	WS	SD	M	Y	?	?	?	R	AD+SP?	R	R	R	S	Y	Y	Y	Y
Telemark(new)	Agripro	SD	EM	Y	Y	?	?	MR	AD	?	?	?	S	?	?	Y	Y
Wampum	WSU	TSD	LM	Y	N	?	?	R	AD+SP	R	S	R	S	Y	Y	Y	Y
WPB906R	WPB	SD	EM	Y	Y	?	?	R	AD+SP	R	R	R	S	Y	Y	Y	Y
Yecora Rojo	Cimmyt-CA	SSD	E	Y	Y	?	?	MS	?	MS	R	R	S	Y	N	N	N

Definitions (1) FL-ML = First line Seeds, Moses Lake; WS = World Seeds; M = meadium; E = early; (EM = early to moderate maturity, etc). (4) Excellent /Satisfactory. GPS-MT = Great Plains Seeds, Montana; NK = Northrup-King. (2) SD = (5) S = susceptible; R = resistant; M = moderately; V = very. (6) AD = semidwarf; SSD = Short semidwarf; TSD = tall semidwarf. (3) Late/ adult plant, non-specific; SP = race-specific resistance.

Table 3

COMMERCIAL VARIETY NURSERY
3 YEAR YIELD AVERAGES (BU/AC)

VARIETY NAME	LIND (BU/AC)	PULLMAN (BU/AC)	ROYAL SLOPE (BU/AC) (IRRIGATED)
	LOCATIONS		
WHITES:			
FIELDER	23.9	69.6	112.3
DIRKWIN	24.2	83.8	109.5
WAVERLY	24.3	77.6	110.3
LANDMARK	21.1	76.4	101.8
EDWALL	26.0	83.1	108.2
BLISS	25.1	80.9	112.2
PENAWAWA	24.6	80.5	116.1
WAKANZ	25.7	86.1	114.8
REDS:			
YECORA ROJO	17.5	66.2	99.4
WAMPUM	24.4	77.1	112.3
MCKAY	23.7	81.4	107.8
NK 751	22.6	79.3	109.3
SPILLMAN	24.5	77.9	106.8
WPB 906R	19.5	78.1	94.8

Table 4

1987 COMMERCIAL SPRING WHEAT TRIAL #46
AGRONOMIC DATA

LOCATION	YIELD (BU/AC) PULLMAN	LIND	ROYAL SLOPE	TEST WEIGHT (LB/BU)	PLANT HEIGHT (INCHES)	HEADING DATE (JUNE)
				PULLMAN DATA		
WHITE SELECTIONS:						
FIELDER	73.1	26.0	118.6	57.9	29	13-Jun
DIRKWIN	107.4	27.9	114.5	60.3	34	14-Jun
WAVERLY	105.5	28.0	119.5	61.2	30	14-Jun
LANDMARK	97.5	21.7	105.5	62.2	31	13-Jun
EDWALL	102.4	27.4	110.9	61.0	30	12-Jun
TREASURE	108.1	29.5	126.1	61.5	32	15-Jun
BLISS	101.2	26.7	122.7	59.6	32	15-Jun
PENAWAWA	109.8	24.6	127.5	60.6	31	14-Jun
WAKANZ	108.4	28.9	117.5	---	32	13-Jun
WA007187	101.5	26.3	118.7	62.8	34	13-Jun
WA007492	111.5	28.6	132.7	62.0	33	14-Jun

Table 5 1987 COMMERCIAL SPRING WHEAT TRIAL #46
AGRONOMIC DATA

LOCATION	YIELD, BU./AC (protein %) PULLMAN	LIND	ROYAL SLOPE	TEST WEIGHT LB./BU	PLANT HEIGHT INCHES	HEADING DATE JUNE
				PULLMAN DATA		
RED SELECTIONS:						
YECORA ROJO	81.6 (13.7)	12.4 (17.7)	99.6 (14.3)	63.2	20	9-Jun
WAMPUM	102.1 (13.0)	27.9 (15.6)	114.0 (13.7)	62.2	35	15-Jun
MCKAY	103.2 (13.0)	23.1 (16.0)	103.1 (13.5)	61.6	32	15-Jun
BUCK MAPUCHE	94.3 (14.4)	22.5 (16.4)	99.6 (15.1)	63.4	30	9-Jun
BRONZE CHIEF	75.2 (14.7)	17.5 (18.2)	97.7 (16.6)	60.5	28	6-Jun
KODIAK	79.5 (---)	15.7 (17.0)	75.4 (14.2)	58.0	18	10-Jun
NORDIC	97.7 (12.3)	26.9 (15.8)	130.3 (13.6)	64.2	33	15-Jun
TELEMARK	82.5 (13.7)	24.5 (16.7)	90.9 (15.2)	62.9	29	10-Jun
CERES	99.4 (12.9)	25.3 (15.6)	117.0 (14.1)	64.0	33	11-Jun
NK 751	104.7 (12.8)	23.9 (15.4)	114.4 (13.6)	63.4	29	9-Jun
COPPER	96.3 (13.5)	21.6 (16.1)	114.0 (14.1)	62.1	31	10-Jun
BUTTE	96.2 (13.5)	25.6 (16.0)	109.8 (15.5)	62.4	32	10-Jun
SPILLMAN	96.3 (14.0)	26.3 (17.3)	105.0 (14.4)	61.4	32	14-Jun
WA007326	97.6 (15.2)	27.3 (16.9)	113.1 (14.4)	62.4	31	13-Jun
WPB906R	96.4 (14.7)	17.9 (17.6)	96.8 (14.7)	62.1	27	7-Jun

Soft White Winter Wheat Improvement

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

Washington wheat growers harvested 113.3 million bushels of wheat in 1987 for an average yield per acre of 56.2 bushels. Grain production increased approximately 7 bushels per acre over the average grain yield in 1986. The winter was very mild and precipitation was below normal. Even though the region received very little snow, dwarf bunt and snow mold were a problem in some areas. Stripe rust was prevalent and may have reduced yields.

Low temperatures that occurred about the middle of May caused considerable damage over a large part of the wheat region in Washington and yield reductions ranged from 0 to 100 percent. Cool weather and timely precipitation helped to make up for the lack of adequate soil moisture in the region.

New Varieties

Madsen

Madsen (WA007163) is a soft white winter wheat with resistance to strawbreaker foot rot. It will be released to the growers in the fall of 1988. Madsen is also resistant to the local races of stripe rust and leaf rust, and it has a good yield potential. It has a common type head with white chaff. The milling and flour quality of Madsen is similar to that of Hill 81. Madsen was developed by ARS-USDA and WSU.

Hyak

Hyak (WA007166) is a semidwarf soft white club winter wheat with resistance to strawbreaker foot rot. It will be released to the grain producers in 1988. Hyak is resistant to the local races of stripe rust and leaf rust, and Hyak has good yield potential. The milling and flour characteristics of Hyak are equal to those of other club varieties. Hyak was developed by ARS-USDA and WSU.

Results

The 1986/87 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 varieties that lack good winter hardiness (Stephens, Oveson and Malcolm) performed well in 1986/87 because of the mild winter. Hill 81 (111 bu/a) produced the most grain of the commercial varieties during 1986/87 in the Pullman late nursery. Stephens was the highest yielding commercial variety at Pomeroy (69 bu/a). The club wheat Tres produced the most grain at Ritzville (69 bu/a). Malcolm produced the most grain in 1986/87 (116 bu/a) at Cunningham (irrigated) and Walla Walla (102 bu/a). The grain yield of varieties with weak straw (Lewjain, Dusty, Oveson, Crew, and Tres) was reduced at Cunningham because they lodged quite early. Sprague (40 bu/a) produced the most grain at Coulee City in 1986/87. When the yields were averaged over the last 4 years Lewjain produced the most grain at Pullman (late) and Tres was the highest yielding variety at Ritzville. Dusty was top at Pomeroy and Walla Walla and Malcolm produced the most grain at Cunningham.

Table 1. Yield data (bu/a) on 11 winter wheat varieties grown at five locations in Washington during 1986/87 and the four year average for each variety at each location. The overall average for 1986/87 and for the last 4 years is also presented.

	PULLMAN L		Pomeroy		Walla Walla		Ritzville		Cunningham		Average	
	87	4 yr AVG.	87	4 yr AVG.	87	4 yr AVG.	87	4 yr AVG.	87	4 yr AVG.	87	4 yr AVG.
Stephens	97	73	69	53	93	92	52	40	112	99	85	71
Daws	100	74	61	60	87	88	55	58	100	111	81	78
Dusty	103	85	63	63	89	99	58	54	80	99	79	80
LEWJAIN	98	80	67	62	87	91	57	60	59	102	74	79
HILL 81	111	81	67	61	93	91	55	52	102	104	86	78
MALCOLM	110	78	68	61	102	93	61	47	116	113	91	78
MADSEN	98	86	60	62	86	92	55	55	93	102	78	79
OVESON	94	80	60	56	93	94	47	37	79	95	75	72
CREW	86	76	67	62	89	88	57	57	67	96	73	76
TRES	96	78	68	60	84	90	66	60	68	96	76	77
HYAK	93	81	63	63	89	96	49	55	78	97	74	78

TABLE 8. EMERGENCE (EM), WINTER HARDINESS (WH), MATURITY (MAT), BUSHEL WEIGHT (BW), COMMON BUNT (CB), DWARF BUNT (DB), LEAF RUST (LR), STRIPE RUST (SR), AND CEPHALOSPORIUM STRIPE (CS) INDEX AND/OR DISEASE RATINGS FOR WHEAT

VARIETY	EM	WH	MAT	BW	CB	DB	LR	SR	CS
NUGAINES	5*	6	MEDIUM	8	R**	S	S	MS	MR
DAWS	4	8	MEDIUM	7	R	S	MS	MR	MS
STEPHENS	5	2	EARLY	7	R	S	MS	R	S
HILL 81	5	5	MEDIUM	7	R	S	MS	MR	MR
LEWJAIN	6	5	LATE	7	R	R	MS	R	MR
DUSTY	5	5	MED-LATE	7	R	S	MS	MR	MS
MALCOLM	5	2	EARLY	7	R	S	MS	R	S
OVESON	5	2	MEDIUM	7	S	S	MS	R	MS
MADSEN	5	5	MEDIUM	7	R	S	R	R	MS
JOHN	6	5	EARLY	7	R	S	S	S	
CREW	6	5	MEDIUM	6	MR	S	MR	MS	MS
TRES	6	5	MEDIUM	7	MR	S	R	S	MS
MORO	8	5	MEDIUM	5	R	MR	S	S	MS
HYAK	6	5	MEDIUM	7	R	S	R	R	MS

RECENT ADVANCES IN WINTER WHEAT GENETICS

R.E. Allan, E. Haro, K.K. Hwu, Y. Hu, L.M. Little,
J.A. Pritchett, D.E. Roberts and S. Wyatt.

The Release of Hyak and Madsen - New Soft White Winter Wheat Cultivars

The USDA-ARS and the Agriculture Experiment Stations of Washington, Idaho and Oregon have jointly released Hyak and Madsen wheat cultivars on January 7, 1988. Hyak and Madsen are soft white winter club and common wheat cultivars, respectively. They were bred and selected by R.E. Allan, USDA-ARS wheat geneticist.

Hyak and Madsen are the first winter wheats in the USA that have resistance to strawbreaker foot rot. Their resistance is derived from a weedy relative of wheat known as *Aegilops ventricosa*. In 1974 Allan obtained two wheat germplasm lines from France, which carried the unique strawbreaker resistance. He used these lines as parents and in 1980 selected F3 lines from the crosses VPM1/Moisson 421//2*Tyee and VPM1/Moisson 951//2*Hill 81 that eventually became Hyak and Madsen, respectively.

The two cultivars have high strawbreaker resistance. Foot rot induced losses of Hyak and Madsen have averaged 1 and 7 %, respectively, vs. losses of 17 to 33 % for Nugaines, Daws, Stephens and Tyee over 6 trials conducted during 1981 to 1986. The mean yields for Hyak and Madsen have averaged 99 and 114 bu/acre versus 68 to 79 bu/acre for Daws, Nugaines, Stephens and Tyee when averaged across the 6 foot rot inoculated trials. When strawbreaker foot rot is not a factor, the yields Hyak and Madsen have generally been competitive with most other commercially grown semidwarf soft white winter wheat cultivars. In 75 Washington State trials, the average yields of Hyak, Crew and Tres have been 71, 70 and 70 bu/acre, respectively. In the same 75 trials, the mean yields of Madsen, Stephens, Nugaines, Daws and Lewjain were 72, 65, 66, 71 and 74 bu/acre, respectively. Across 24 regional trials in Oregon, Idaho and Montana, Hyak and Tres have both averaged 70 bu/acre. In the same 24 regional trials Madsen, Nugaines, Stephens and Dusty have averaged 83, 72, 82 and 84 bu/acre, respectively.

Both Hyak and Madsen have combined resistance to all three rusts. They are both susceptible to Cephalosporium stripe and have only partial resistance to common bunt. Hyak and Madsen are susceptible and resistant to Powdery mildew, respectively.

The grain volume weight of Hyak is similar to Crew, heavier than Tyee but is about 1.3 lbs/bu less than Tres. Madsen has a mean grain volume weight that is about 1 lb/bu heavier than Stephens and 1.4 lbs/bu lighter than Nugaines.

Hyak is comparable to Tyee for coldhardiness, plant height and lodging resistance. Madsen is similar to Daws for plant height. It is less prone to lodging than Lewjain and Dusty but more likely to lodge than Stephens. Madsen appears similar to Stephens for coldhardiness. It emerges faster than Daws, but slower than Stephens. Madsen has a tendency to shatter.

Tests by the USDA-ARS Western Wheat Quality lab have rated both Hyak and Madsen promising to particularly promising for overall soft white wheat quality. Hyak is like Tres for cookie diameter, sponge cake score and flower yield; it is like Moro for cake volume and noodle score. Madsen usually rates above Nugaines and Stephens for cookie diameter, sponge cake score and cake volume. It equals or exceeds them for noodle score.

Madsen was named for former Dean and Director Louis Madsen, who was Director of the WSU Agricultural Experiment Station from 7-1-55 to 6-30-1964. He was Dean of the College of Agriculture from 7-1-1965 to 7-1-1973. Dean Madsen did much to improve and strengthen the cooperative relationships between Washington State University and the USDA-ARS wheat research program. Hyak was named after a small Kittitas County community in the Cascades. Foundation seed of both cultivars should be available in the fall of 1988.

<u>Adapting Winter Wheat to No-till Management</u>

Dr. Kae-Kang Hwu completed a 5 year study that assessed the use of natural selection to develop winter wheat cultivars specifically adapted to no-till management. He subjected 18 wheat populations to 5 cycles of natural selection under the contrasting management systems of no-till versus till culture. The year-to-year changes in the populations under the two contrasting tillage practices were monitored by measuring grain yield, biomass yield, tiller number, seed weight, grain weight, harvest index and kernels/spike. In nearly all of the populations, the 5 cycles of natural selection failed to modify them toward enhanced fitness for no-till culture. In one genetically diverse population, grain and biomass yield were significantly increased after the 5 cycles of natural selection under no-till. An important conclusion was that given sufficient genetic variability, selection gain for increased grain and biomass yield could be achieved by exposing populations to natural selection under no-till conditions.

Shifts occurred for specific genes among individuals within several of the populations. For instance, the proportion of individuals with red glumes, club spikes and awned spikes increased under no-till versus till management.

Individual seeds of several of the populations were examined for their gliadin protein electrophoretic banding patterns throughout the course of the study. Moderate to dramatic divergent changes occurred among most of the populations under the two management systems. This finding conclusively proved that the genetic structures of these winter wheat populations were altered quite differently by no-till versus till culture. Evidence was obtained that specific gliadin coding genes were linked to unknown no-till adaptive genes in four of the populations. For instance, two gliadin alleles derived from Paha and Barbee were associated with unknown fitness genes for till culture whereas two gliadin alleles from Early Blackhull were related to unknown fitness genes for no-till culture. Dr. Hwu's results represent the first conclusive evidence that a separate breeding program for no-till culture would be justified.

Yield and Yield Stability Comparisons of Multilines vs. Pureline Cultivars

Mean grain yields and stability parameters of 16 club soft white winter (SWW) wheat multilines were compared to club (Paha, Barbee, Tyee, Tres) and common (Nugaines, Stephens, Daws) Pacific Northwest SWW cultivars. The multilines comprised from 5 to 23 components and possessed resistances to stripe rust and in some cases leaf rust. Tests spanned 10 to 48 trials conducted during 1979 to 1986. The multilines had across-trial mean yields that were competitive with those of the cultivars and equalled or exceeded individual cultivar mean yields in 87 of the 112 comparisons. Seven multilines had mean yields equal to or higher than all of the cultivars. Yield stability of each multiline and each cultivar were directly compared. As a group the multilines did not express greater yield stability than the cultivars across the test environments. As with cultivars, individual multilines expressed either low or high yield stability. The only multiline with both high mean yield and high stability was Crew. Four recently synthesized multilines yielded 99 to 103% of the highest yielding cultivar. However, none of these multilines rated particularly high for yield stability.

Genetic Tests on Seed Dormancy in White Wheat

Preharvest sprouting in the field continues to be a serious problem of soft white wheat (SWW) production in the Pacific Northwest. Brevor and Clarks Cream are two white-seed cultivars that we are using as sources of seed dormancy in breeding for resistance to pre-harvest sprouting. Tests were conducted during 1986 and 1987 on field grown seed of the F_3 and F_4 progenies and parents of the cross Clark's Cream/Brevor. The degree of dormancy of the lines and parents was assessed by calculating their germination indices based on 7 successive daily germination counts at 30°C. Progeny transgressed the two parents for higher and lower seed dormancy at 30°C. Moderate (h^2=0.39) and low (h^2=0.17) heritabilities for expression of dormancy were measured based on the standard unit and parent/offspring regression methods, respectively. Apparently, Brevor and Clark's Cream differ by one or more genes for seed dormancy. About 3% of the progeny were more dormant than both parents during both years. These highly dormant lines should have genetic potential for enhanced resistance to preharvest sprouting and will undergo further testing.

<u>Breeding for Tolerance to Barley Yellow Dwarf Virus</u>

A diallel selective mating series was initiated by making the primary crosses among four adapted soft white winter wheats (Daws, Dusty, Lewjain, and Tres) to five sources of BYD tolerance (CI 13232, Elmo, Nova Sad 874, Roland, and Yamhill). The hybrids were fall-sown in 1987 and have survived the winter. The 10 possible crosses will be made this summer among F_1 plants of the 5 crosses representing each of the adapted parent by BYD tolerant parent combinations. Progeny from these four diallel series will be subjected to BYD infection and the second series of intermatings will be made among those individuals expressing the highest tolerance.

Approximately 70 crosses were made involving adapted cultivars Daws, Dusty, Lewjain, Madsen and Hyak to four Daws/Elmo F_7 lines that have expressed moderately high tolerance to BYD. The F_1 parents of these crosses have survived the winter and F_2 progeny will be sown the fall of 1988. The four Daws/Elmo F_7 lines were placed in three 1987 yield trials. Three lines (87465, 87466, and 87468) equaled or exceeded the mean yields of Daws in all three trials and across trials. Selection 87465 and 87466 have adequate field resistance to stripe rust but 87468 is moderately susceptible. Selections 87465 and 87466 also have moderately high leaf rust resistance and have been placed in four 1988 yield trials.

Over 200 F_4 lines of Elmo/2*Daws and Elmo/2*Nugaines populations were grown in a preliminary yield trial. Several of these lines were identified to have useful tolerance to BYD in 1987. These lines either expressed homozygous or heterozygous nonspecific resistance to stripe rust. Approximately 200 F_5 plant selections were made from these lines and were sown in our 1988 head row nursery where they will be screened for stripe rust, leaf rust, and common bunt resistance.

HARD RED WINTER WHEAT BREEDING AND TESTING

E. Donaldson, M. Nagamitsu and Bruce Sauer

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, consistently 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, which include 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 rust, 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.

Hard red winter wheat selections being considered for release include ID000297 - Blizzard and ID000332 - Survivor (developed by USDA and the University of Idaho). Both selections are tall and have good snowmold and TCK resistance. Protein content and stand establishment abilities appear to be satisfactory to good. Stripe rust resistance of Blizzard is probably adequate for most years. Blizzard's yields have been marginal. With only one years' data in Washington for Survivor, the data indicates that yield and stripe rust resistance may not be adequate. ORCE8313 (developed by Oregon State University) is a semidwarf with good protein content and excellent lodging resistance. Winterhardiness and emergence weaknesses may prevent growing this variety in the lower rainfall portion of the summer fallow areas of Washington. WA007523 is a tall selection with improved emergence capabilities and fair resistance to snowmold. Its yield record is excellent. Weaknesses are poor straw strength, minimum stripe rust resistance, and low protein content of the grain.

The 1987 performance of four 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 variety was Weston with 34 bushels per acre. Hatton and Batum averaged 32 bushels per acre. Andrews had extensive mouse damage in each plot in the Finley, Connell and Lind nurseries, and averaged only 19 bushels per acre, overall. In a four year average of these nurseries, Hatton, Batum, Weston, and Andrews yielded 34, 33, 33, and 27 bushels per acre, respectively. Average percent whole grain protein contents on an as is moisture basis for 1987 were 12.1, 12.0, 12.7, and 12.1 for Weston, Batum, Andrews, and Hatton, respectively. Four year average whole grain protein contents were 13.4, 12.9, 12.8, and 12.3 percent for Andrews, Weston, Batum and Hatton, respectively.

Table 1. Summary of agronomic characteristics of winter wheat varieties grown at Lind, 1952 - 87.

Variety	Ave. Plant ht.	Ave. Test wt.	1987 Yield bu/a	Ave. Yield bu/a	Yield % Karkhof	No. years grown	% Protein 1987	% Protein 4 yr ave.
Nugaines	26	61.2	19.5	34.6	123	23		
Dusty	24	60.0	27.2	28.2	135	5		
Lewjain	26	59.4	21.2	30.6	123	11		
John	26	59.9	21.8	29.8	114	7		
Stephens	26	58.2	16.8	29.7	116	15		
Hill 81	26	59.0	19.9	25.8	98	6		
Madsen	25	57.8	17.1	24.6	85	4		
Moro	30	58.5	22.5	34.1	119	24		
Crew	26	58.2	16.3	31.8	126	10		
Tyee	26	58.4	12.7	29.6	106	12		
Tres	26	59.9	19.2	31.4	119	8		
Hyak	24	59.3	7.4	22.1	42	4		
Wanser	31	61.5	29.0	32.6	114	24	13.3	---
Hatton	30	62.4	26.8	31.4	126	12	14.2	13.5
Weston	33	61.4	28.1	31.0	123	10	14.4	14.0
Batum	27	60.2	28.7	35.2	135	7	13.7	13.3
Andrews	27	60.4	16.1	27.9	105	6	15.1	14.2
Kharkof	33	60.6	28.8	28.5	100	33	13.8	---

Influencing 1987 results: Late May frost did extensive damage to selections in a susceptible growth stage. Mouse damage was severe on earlier maturing selections, such as Andrews.

Table 2 . Summary of agronomic characteristics of winter wheat varieties grown near Waterville, 1952 - 87.

Variety	Ave. Test wt.	1987 Yield bu/a	Ave. Yield bu/a	Yield % Karkhof	No. years grown	% Protein 1987	% Protein 4 yr ave.
Stephens	59.2	23.5	36.4	132	8		
Lewjain	61.4	26.3	44.0	164	6		
Sprague	61.0	31.0	44.5	149	11		
John	61.3	24.7	41.9	157	6		
Crew	60.2	24.9	35.4	129	5		
Tres	60.8	28.7	29.7	118	3		
Wanser	58.7	26.4	35.2	112	19	11.4	---
Hatton	63.6	20.9	33.3	130	9	12.0	12.8
Weston	62.3	32.1	34.0	123	8	11.8	13.0
Batum	60.2	26.1	35.4	134	7	11.3	11.2
Andrews	60.6	30.5	39.8	149	6	11.9	12.4
Kharkof	61.1	17.7	31.7	100	28	12.3	---

Influencing 1987 results: Mild snowmold reduced the stands and yields of susceptible selections.

Table 3 . Summary of agronomic characteristics of winter wheat varieties grown at Connell, 1975 - 87.

Variety	Ave. Test wt.	1987 Yield bu/a	Ave. Yield bu/a	Yield % Karkhof	No. years grown	% Protein 1987	% Protein 4 yr ave.
Lewjain	61.2	30.2	38.9	128	5		
John	61.2	30.8	38.4	127	5		
Stephens	59.8	21.1	36.3	122	10		
Tres	61.7	41.0	48.2	132	3		
Wanser	62.5	32.5	34.6	114	11	13.5	---
Hatton	63.4	34.9	38.6	130	10	13.0	13.2
Weston	63.1	32.8	38.3	129	8	13.0	13.9
Batum	61.0	30.9	38.7	127	5	13.4	14.3
Andrews	61.2	15.7	36.8	121	6	14.3	14.3
Kharkof	61.7	25.8	30.5	100	11	13.9	---

Influencing 1987 results: Some frost damage occurred in May. Mouse damage was severe on early maturing selections, such as Andrews.

Table 4 . Summary of agronomic characteristics of winter wheat varieties grown at Finley, 1984 - 87.

Variety	1987 Yield bu/a	Yield % Karkhof	Ave. Test wt.	No. Years Grown	% Protein 1987	% Protein 4 yr ave.
Wanser	36.7	98	62.1	4	11.9	----
Hatton	45.0	128	63.4	4	11.5	12.1
Batum	49.7	114	61.3	4	10.5	12.9
Weston	48.9	118	62.8	4	11.2	13.0
Andrews	30.9	83	61.2	4	11.9	13.5
Kharkof	37.1	100	61.8	4	12.1	----

Influencing 1987 results: Severe mouse damage on early maturing selections, such as Andrews.

Table 5 . Summary of agronomic characteristics of winter wheat varieties grown at Horse Heaven Hills, 1951 - 87.

Variety	1987 Yield bu/a	Yield % Karkhof	Ave. Test wt.	No. Years Grown	% Protein 1987	% Protein 4 yr ave.
Wanser	21.6	113	62.4	4	10.1	----
Hatton	21.0	114	63.7	4	9.6	10.3
Batum	18.3	108	60.8	4	10.4	10.6
Weston	24.7	112	63.0	4	9.8	10.7
Andrews	12.5	106	61.3	4	9.4	11.5
Kharkof	19.9	100	62.3	4	8.0	----

Influencing 1987 results: Fall stands of most selections were poor due to rain between seeding and emergence.

BARLEY BREEDING AND TESTING IN WASHINGTON

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

Production

Barley production in 1987 in Washington was approximately 0.85 million tons (35.5 million bushels) from 645,000 acres. The state average yield was about 1.3 tons/acre (55 bushels/acre). Washington was the fifth largest barley producing state in the U.S. The top six of eight barley varieties grown in 1987 were WSU releases. In rank order, the top five were Steptoe, Boyer, Kamiak, Clark and Showin. The planting projection for Washington for 1988 indicates that there will be about 530,000 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 spring and winter varieties that are adapted to the different barley producing areas of Washington and that have superior quality. Spring barley is emphasized in the program. 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. 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 the 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, Creston, Deep Creek, Reardan, Bickleton, Goldendale, Mayview, Clyde, Anatone, St. John, Uniontown, Fairfield and Farmington are additional extension test locations. The cooperation of C. J. Peterson, 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. The effects of no-till and nitrogen levels has been or 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, Pomeroy and Pullman.

Results

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

Winter Barley

Winterhardiness was not as big an issue this year as emergence through the persistently dry fall. Spotty stands were common, and where late emergence occurred, growth stage and maturity differences were great within a field or plot. The performance of Showin has generally been inconsistent in the past few years especially over dryland eastern Washington locations. However, because of the short stature and lodging resistance, its potential for irrigated production is being evaluated at Othello and Prosser. Results of the irrigated trials from 1987 are presented in Table 2. Newer advanced breeding lines with high yield potential are also presented in Table 1.

Spring Barley

Spring barley performance is presented in Tables 3-6. 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 several locations (Tables 3,5,6). Several advanced breeding lines have performed quite well especially the 2-row WA8771-78. Proprietary varieties, all feed types, are compared in Table 4. The performance of selected varieties and lines in the annual cropping (planting on recrop ground) experiment are presented in Table 5. Spring barley performance of selected varieties and lines at Lind and Harrington are presented in Table 6. WA8771-78 again performed well here indicating adaptation to a broad range of conditions.

Table 1. Winter barley agronomic performance

Variety	Pullman	Pomeroy	Dayton	Walla Walla	14 Loc-Yr Average	Test wt	Plump	Height	Lodging
	Yield (Tons/Acre)					lb/bu	%	in	%
2607-80	3.1	2.2	2.5	2.8	2.7	48	77	35	0
1574-77	2.9	2.4	2.3	2.5	2.6	49	65	34	1
HESK	2.8	2.2	2.4	2.6	2.5	49	61	36	6
BOYER	2.6	2.1	2.6	2.6	2.5	49	67	36	2
SHOWIN	2.4	1.9	2.4	2.3	2.3	48	54	29	0
KAMIAK	2.3	1.6	2.0	2.2	2.1	51	65	41	36

*PU-5 YR; PO, DA, WW - 3 YR

Table 2. Winter barley 1987 irrigated yields* (lb/a)

			IAREC-PROSSER				
Variety	Lind	Othello	Headq(U)	Headq(P)	Rosa(U)	Rosa(U)	Average
2607-80	3920	--	--	--	--	--	--
Showin	3580	5250	3590	4070	7000	9050	5420
Hesk	2630	6440	3550	4370	7610	9700	5720
Boyer	2200	4760	3250	4600	5820	8430	4840
Scio	2130	5040	2570	3330	6520	7980	4590
Kamiak	850	4550	2620	3040	6980	7300	4220

U - unprotected; P = protected from aphids
*Data courtesy: Ed Donaldson, Lind; Ted Wagner, Othello; Keith Pike, Prosser

Table 3. Spring barley state dryland nurseries, 8 years (1980-87)

Variety	Yield (t/a) Pullman	Pomeroy	Dayton*	Walla Walla	Average	Test wt lb/bu	Plump %	Height in	Lodging %
6-row					32 loc-yr				
Cougbar	2.5	1.6	1.5	1.8	1.8	51	81	36	13
Steptoe	2.4	1.7	1.7	1.8	1.9	49	90	36	27
Advance	2.2	1.6	1.5	1.7	1.7	49	74	33	18
Morex	1.8	1.3	---	1.4	1.5**	51	86	41	27
2-row					29 loc-yr				
8771-78	2.3	1.8	1.5	1.8	1.9	53	91	35	19
Andre	2.2	1.8	1.5	1.8	1.9	53	79	35	18
Clark***	2.2	1.5	1.5	1.9	1.9	53	90	37	21
Klages	2.1	1.6	1.3	1.7	1.7	52	81	36	18

* 5 years for 2-rows
** 24 loc-yr average
*** Clark Pu. 8 yrs; Pom., Day, WW 3 yrs; 17 loc. yr. avg.

Table 4. Spring proprietary barley yield averages (lbs/acre)

Variety	Pullman 1987	Pullman 3 year avg.	Royal Slope* 1987	Royal Slope* 3 year avg.	6 loc-yr average
Steptoe	6520	4880	8100	7100	5990
Piston	6550	4830	6970	--	--
Lindy	6070	4820	8140	--	--
7773-83	6000	4700	6080	6340	5520
Columbia	6800	4610	6910	6910	5760
Gus	6120	4320	6700	6150	5230

* Irrigated

Table 5. Spring barley annual cropping experiment

Variety	Row type	Yield (lb/a) Average 1987	Pullman 1987	Pullman 85-87	Davenport 1987	Davenport 85-87	Connell 1987	Connell 85-87	9 loc-yr average
8771-78	2	3070	4360	4690	2390	2520	2450	2030	3080
10217-83	6	3040	4320	--	2130	--	2660	--	--
Steptoe	6	3030	4530	4930	2620	2380	1950	1840	3050
7773-83	2	2960	4020	--	2340	--	2510	--	--
Clark	2	2920	3940	4390	2340	2480	2480	2060	2980
Andre	2	2850	3980	4420	2070	2100	2490	1970	2830
8707-80	6	2850	4190	--	2150	--	2200	--	--
12809-83	6	2790	4180	--	1930	--	2270	--	--
Cougbar	6	2660	3980	4680	1730	1950	2270	1850	2830
Wanubet	2	2390	2950	--	2210	--	2010	--	--

Table 6. Spring barley extreme dryland nursery yields (lbs/acre)

Variety	Lind		Harrington		6 loc-yr Average
	1987	3 Year Avg.	1987	3 Year Avg.	
8771-78	1530	1600	1700	1930	1770
Steptoe	1330	1460	1380	1930	1770
Clark	1550	1520	1440	1840	1680
Andre	1350	1420	1390	1800	1610
Cougbar	1390	1310	1180	1740	1530

TRITICALE

C.J. Peterson, D.F. Moser, and K. Hinnenkamp

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. New cultivars are similar to wheat in grain production and the bushel weight, although still low (approximately 50 pounds per bushel), has been improved. Seed dormancy and head shattering characteristics of triticale is similar to wheat. Therefore triticale does not present the same volunteer problem as rye.

George Varughese reported in 1986 that approximately 1,850,000 acres of triticale were grown in some 30 different countries in the world. More than 55 triticale cultivars have been released. These triticale cultivars were grown for forage and/or for the production of grain. Before 1986 most of the triticale production in the United States was for forage.

Cultivars

Both winter and spring triticale cultivars have been developed for production in the Pacific Northwest.

Winter Triticale

Flora, a winter triticale, was developed and released from the cooperative USDA/Agricultural Research Service - Oregon State University triticale program. Flora is a high yielding, semidwarf triticale that has a very low bushel weight (approximately 40 to 45 pounds per bushel). Plant height of Flora is similar to that of the semidwarf wheat cultivar, Daws. Flora, like most triticale cultivars, is quite susceptible to Cephalosporium stripe.

Spring Triticale

Grace (also known as Palouse) is a spring triticale that was developed (selection identified by USDA/Agricultural Research Service - Washington State University program) by the Jenkins Foundation in California. Grace is a mid-tall (38-45 inches) triticale with good yield potential. It has some tolerance to freeze damage and has been grown at Pullman, Washington, from both fall and spring seedings. The kernels of Grace are quite shriveled and therefore the bushel weight is about 10 pounds below that of wheat.

Whitman (VH080011) was developed and released from the cooperative USDA/ARS - Washington State University triticale breeding program. It is a spring triticale but 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 has a good grain yield potential from both winter and spring plantings. 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 of Whitman is 1 to 2 percentage points above that of the soft white winter wheat cultivars.

The spring triticale, Juan, was (developed by CIMMYT and University of California at Davis) released to the growers in California in 1984. Juan has performed quite well in the Pullman nurseries. Juan is a mid tall (38-45 inches) triticale and has a very good yield potential. Bushel weight and protein content of the grain is quite similar to that of Whitman. Unlike Grace or Whitman, Juan does not respond to photoperiod and it may head in the fall from an early seeding (August or 1st part of September).

There are a number of private triticale cultivars available that we have not tested.

Disease

Triticale is susceptible to most of the plant diseases that attack wheat. Although early triticale cultivars exhibited good resistance to most plant diseases this has changed as production increased. Leaf rust, stem rust and stripe rust have become major deterrents in the production of triticale in Australia. In the Pacific Northwest triticale is quite susceptible to Cephalosporium stripe and ergot is sometimes a problem.

Seeding

Higher seeding rates are required for triticale than wheat because there are fewer triticale seeds per pound and the triticale plants tiller less than wheat. The seeding rate for triticale should be approximately 20 percent higher than that for wheat. Seeding date in the spring should be as soon as it is possible to till the soil properly, and in the fall follow the same seeding dates for your area as for wheat.

Fertilizing

The nitrogen, sulfur, and phosphorus requirements for triticale are similar to that of wheat. Therefore, the fertilizer program for triticale should be the same as that used for wheat in accordance with fall or spring plantings.

Weed Control

Use the same herbicides as those recommended for wheat provided they are labeled for use on triticale or small grains. The cultivars vary in their response to herbicides and some of them show considerably more yellowing than others following treatment. This usually does not result in a yield depression.

Protein Content

Protein content of the triticales has decreased as the yields have increased, but it is generally one to three percentage points above that of the commercially grown wheat cultivars.

Forage Production

Planting triticales for use as annual forages or pasture may offer flexibility in managing 'set-aside' acres not allowed for production of other cereals under existing government programs. Both spring and winter triticales offer good potential for annual forage production in the Pacific Northwest, and may offer the best combination of forage yield and crude protein compared to other annual spring grains. Ciha reported average harvests of 4.7 tons of dry matter per acre for two spring triticales compared to 5.7, 5.4, and 3.6 tons of dry matter per acre for spring barley, oat, and wheat crops, respectively. Average crude protein was 8.6, 7.5, 9.5, and 9.3 percent of dry matter for barley, oat, wheat, and triticale forage, respectively.

Forage quality of triticales and other small grains usually decline just beyond the headed stage of growth, whereas forage yields of small grains peak at the soft-dough stage of kernel development. Maximum crude protein levels in dry triticale forage and triticale silage have been attained for crops harvested at the late-boot to fully headed stage of development. In Washington, delaying harvest of triticale from just headed until the soft-dough stage resulted in 3.5 additional tons of dry forage per acre but only produced an additional 80 pounds of crude protein per acre. Establishing mixed stands of triticale with an annual legume such as peas or fababeans, may improve forage protein levels at later harvest dates similar to results obtained with mixed winter pea/winter barley and winter pea/winter wheat forage crops.

Markets

Triticale is a good feed for livestock, especially swine and poultry. Produced under the same conditions, triticale has a higher protein content than wheat or barley. Lysine (the usually limiting essential amino acid) content is also higher in triticale than in wheat thus increasing it's feed value for swine and poultry. Compared with corn, barley, and wheat, triticale reduces the requirement for more expensive protein supplements.

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

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 nonmottled 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. An earlier maturing Laird type was recently released and should be available to growers in 1989. 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.

'Palouse' (selection WA256112), released in 1988, is a large-seeded yellow cotyledon lentil that is similar in size to the Canadian Laird lentil. However, Palouse is earlier to mature and is comparable to Brewer for yield. Palouse also has seeds that are free from mottling.

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 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 were released 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 weigh 16.4 grams per 100 seeds.

The current problem of Ascochyta blight on chickpeas in the Idaho-Washington area has prompted research on identification of resistant lines. Seven lines with excellent resistance to blight are currently being studied for their potential as resistant cultivars.

CROSS-SLOT DRILL FOR CONSERVATION TILLAGE

Dr. Keith E. Saxton

BACKGROUND - A new and innovative conservation tillage grain drill has been developed by USDA-ARS, Pullman, WA, which shows excellent promise to significantly enhance the adaptation of conservation tillage on cereal grain farmlands. This drill, which was developed in cooperation with Massey University in New Zealand, features a Cross-slot (Bio-blade) opener which has a number of advantages over conventional double-disk and hoe-type openers used on most conservation tillage planters. This Cross-slot opener uses a single coulter with attached side blades to simultaneously place seed and fertilizer while easily passing through heavy surface residues without plugging or tucking the residues into the seed furrow.

Conservation tillage with fertilizer placement offers high potential for reducing erosion, improving fertilizer efficiency, and reducing impairment of surface and ground water quality. Requirements of the Food Security Act of 1985 makes it imperative that conservation tillage become feasible for many farmland situations as soon as possible. This new drill has that potential within the time frame of conservation compliance.

STATUS - We have built and tested a research version (8 foot wide) of the Cross-slot grain drill. Results from three drilling seasons have shown excellent success in a wide variety of drilling situations. This research has involved close cooperation with the New Zealand scientists to adapt this technology to our agriculture.

In addition, a local commercial company, United Agricultural Systems, has built a prototype field scale machine (24 foot wide) based on our technology and their results were excellent on several thousand acres of fall and spring seeding. This company has now obtained necessary patent licensing to begin producing commercial machines in the next several months.

FUTURE - Additional research will be conducted to further define the operating characteristics of the Cross-slot opener. Experiments are in place to test the seeding of most local crops in a wide variety of residues. Experiments are also in progress to determine the best fertilizer placement position and any necessary opener modifications for various fertilizer forms and rates. In addition, a wide-ranging series of research trials will be conducted in cooperation with other USDA-ARS research stations and conservation agencies such as USDA-SCS, Soil Conservation Districts, and Cooperative Extension. These trials will be in a wide variety of locations throughout the western dryland farming region to include many varied and local situations.

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

Roland F. Line
USDA, Plant Pathology

General Characteristics. Three rusts (stripe rust, leaf rust, and stem rust) occur on wheat in the Pacific Northwest. Stripe rust appears as golden-yellow, long, narrow stripes on the leaf surface and glumes; leaf rust appears as small, red pustules on the leaf surface and leaf sheath; and stem rust appears as larger, red-brown, diamond-shaped pustules on the leaf surface and stems. Stripe rust and stem rust can also occur on the heads. Stripe rust and leaf rust overwinter on wheat and rapidly increase during the spring. Stripe rust develops during the cool temperatures of early spring. Leaf rust develops at warmer temperatures later in the spring. The stem rust pathogen does not usually survive on 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 19 of the last 25 years. Stripe rust reduced yields in the Pacific Northwest by more than 20 percent in 1981 and more than 15 percent in 1983 and 1984. 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 14 years, leaf rust has caused severe losses in every year except 1977, 1979, 1982, 1985, and 1986. Leaf rust has caused severe losses in irrigated fields in almost every year. Losses caused by leaf rust in irrigated fields have sometimes exceeded 60 percent. In 1980, 1981, 1983, and 1984, stem rust caused significant damage to wheat and barley in eastern Washington and Oregon and northern Idaho, especially in late maturing fields.

Monitoring Rust. Thirty-eight races of _Puccinia striiformis_, the pathogen that causes stripe rust, have been identified. Races virulent on Fielder, Moro, Jacmar, Barbee, Faro, Weston, Tyee, Hatton, Tres, and seedlings of Stephens, Hill 81, and Daws were most prevalent in 1987. No significant new races of *Puccinia recondita*, the pathogen causing leaf rust, were detected in 1987. Most winter wheat varieties currently grown in the region are very susceptible to leaf rust. Since the current races can attack most varieties, there is 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. Since the continual presence of living wheat plants throughout the year provides adequate inoculum for the initiation of new stripe rust and leaf rust epidemics and many current varieties are susceptible to the races of rust that occur in the region, the most limiting factor is the weather. When used in combination with monitoring data, a model for predicting stripe rust, based on winter and spring temperatures has proved to be reliable since 1979, and when used with precipitation data it has enabled prediction of leaf rust and stem rust. An unusually dry season and cold winter in 1987 prevented development of extremely severe rust epidemics in 1987. Stripe rust and leaf rust should not be severe in 1988 because of the extremely dry weather during the fall of 1987 and the early winter of 1988. The severity could shift if cool wet weather occurred in May and June.

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. Information on the characteristics and inheritance of HTAP resistance in Gaines, Nugaines, Luke, Stephens and Daws (five varieties with different levels of HTAP resistance and different genes for resistance) has been obtained based on analysis of advanced progeny from crosses of the varieties and crosses with a susceptible club wheat. The HTAP resistance that was transferred into the club wheat may be useful in developing club wheats with better stripe rust resistance. Also, new information on the inheritance of race-specific resistance has been obtained and should be useful in developing new disease control programs, identifying races, and understanding how resistance works.

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 1987, more than 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 a better understanding of how to use resistance and 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. A new chemical, Tilt, has recently been registered for rust control. Guidelines for the use of the chemical have been developed based on type of rust, type of resistance, intensity of rust, stage of growth, potential yield, and economic return. New fungicides that show greatest promise as foliar applications for control of stripe rust, leaf rust and stem rust are Folicur and Summit developed by Mobay, Spotless developed by Chevron, and a numbered compound developed by BASF. Baytan, a seed treatment developed by Mobay, has potential as a early season control of stripe rust and leaf rust, and it should be registered in the near future. However, it can delay emergence under some conditions; therefore, it will have to be managed carefully. Research on reducing the emergence problem is currently being conducted.

STRAWBREAKER FOOT ROT AND CEPHALOSPORIUM STRIPE

Timothy Murray, Cheryl Campbell, and Carl Strausbaugh

Strawbreaker foot rot and Cephalosporium stripe are important diseases of winter wheat, especially wheat seeded early on summer fallow. Both diseases are most prevalent in areas of eastern Washington with more than 16" annual rainfall and where crop rotations are short. Yield losses of 50% can occur with strawbreaker and up to 100% when cephalosporium stripe is serious.

Strawbreaker foot rot is controlled with an application of Benlate, Mertect, or Topsin-M in the spring. These three fungicides will give comparable control and yield responses under light to moderate disease pressure. One of the goals of this research program is to insure the availability of effective fungicides for control of strawbreaker foot rot. One potential problem for eastern Washington, and one that has occurred in Europe, is the development of resistance to Benlate, Mertect, or Topsin-M in the fungus that causes foot rot. Three new fungicides are being tested for use in combination with the current commercial fungicides: DPX H6573, and experimental fungicide from DuPont; Prochloraz, a fungicide used in Europe in combination with Carbendazim for foot rot control; and Tilt, a fungicide currently registered for rust control in wheat. Last year under severe foot rot conditions, all three of the new fungicides provided good disease control and significant yield increases when used in combination with Benlate. It may be possible to introduce one of these combinations for commercial use within 3 years.

Another control for strawbreaker foot rot is resistant varieties. This fall the first commercially-available foot rot resistant varieties, Hyak and Madsen, will be released as foundation seed. Incorporating resistance into commercial varieties has been difficult. The mechanisms and genetics of resistance are not well-understood. We are studying resistance to try and understand what makes a plant resistant and how resistance is controlled genetically. We have developed a seedling test that we hope will speed-up screening and development of resistant varieties. Currently Carl Strausbaugh is studying the genetics of resistance in seedlings. He has found that resistance in controlled by one or two genes, but that environment has a large effect on the expression of resistance, and hence, the ability to identify resistant plants with certainty. We are also studying the genetics of resistance in adult plants in the field to back-up the results from the lab and greenhouse. 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 such as 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 it we can use increased soil acidity to increase disease and screen for resistance. Field experiments are in progress 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, although yield increases were not significant because overall disease severity was low. We are continuing these studies in small scale plots and hope to establish larger plots this year.

TAKE-ALL

R. J. Cook and D. M. Weller

Take-all is a problem in areas receiving at least 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. A survey in 1983 indicated that about 625,000 acres of wheat were affected by take-all in the three northwest states that year, about half in Washington. Take-all 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 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. The disease is very sensitive to soil drying. Pivot irrigation is especially favorable to the fungus. Thorough tillage helps control the disease by accelerating the death rate of the fungus, but should be considered as an option for take-all control only if a rotation is not followed. 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 monoculture of wheat (take-all decline), because of a natural biological control, but is effective only if some tillage is used. Moreover, we have now shown in a long-term (20-year) trial with continuous irrigated wheat at Lind that as take-all declined, Rhizoctonia root rot increased.

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 to protect the roots. An average yield increase of 10-15 percent has been obtained in 10 trials carried out since 1982 in commercial fields where take-all was the main yield-limiting factor. 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); the fungus uses nutrients from straw and chaff as a food source and 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 biological or chemical 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. Moreover, we now have evidence that where Rhizoctonia and Pythium root rots occur as a mixture, control of only Pythium root rot with Apron can have a negative effect on the wheat, possibly by increasing Rhizoctonia root rot.

The only field treatment effective at present against root infections is fumigation of the soil with chloropicrin or Telone C17, but the effective rates are uneconomical. In contrast, low rates of metham sodium (e.g. 4-5 gal/A) might be economical but in our trials they have been ineffective.

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 fairly new or current year seed.

RHIZOCTONIA ROOT ROT

R. J. Cook and D. M. Weller

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. Since then, this disease has been found in many fields in eastern Washington, and has occurred in devastating amounts in some cases. 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. Winter and spring cereals all are susceptible, but spring barley is affected more severely than any other crop grown in the dryland Inland 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. Cheatgrass is also very susceptible and can serve as a reservoir of inoculum of the fungus.

Rhizoctonia root rot is favored by continuous cropping of winter and spring cereals and by reduced or no tillage. A full year of clean fallow (no weeds or volunteer) helps greatly to lower the amount of fungus to safer (less damaging) populations. No-till is relatively risk-free if following a clean 1-year break (regular or chem fallow). Alternatively, the disease can be controlled to a significant extent (but not completely) in continuous cereals (wheat or barley) if some tillage is used. The highest risk of disease occurs with continuous no-till wheat or barley. The lowest risk is with winter or spring cereals grown after a full year of conventional tillage.

Significant disease control can be achieved with spring wheat or barley seeded into stubble if the weeds and volunteer are killed well in advance of planting. By this approach, the potential host plants of Rhizoctonia do not become large reservoirs of the fungus. If glyphasate is used, the chemical should be applied in the fall, or at least 2-3 weeks before planting in the spring (if possible) to allow time for the fungus population to peak and then subside on the roots of the dying grass hosts and volunteers. The greatest amount of this disease in continuous cereals with minimum or no tillage has occurred where glyphasate was applied only a few (e.g. 3) days before sowing into lush (but dying) cover of cheatgrass and volunteer wheat.

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

SUMMARY OF ACTIVITIES OF THE USDA WESTERN WHEAT QUALITY LABORATORY

Evaluation of end-use milling and baking quality of 1849 experimental wheat germplasm lines (F_5 and later) grown in the western states and harvested as the 1986 crop were made. These included 772 (from WA), 714 (OR), 62 (ID), 956 (CA), 115 from the Western Regional Nurseries, and 230 from commercial and/or other sources. To-date analysis and evaluation has been completed on about 1600 selections from the 1987 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 24% 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 892 F_4 generation samples from the 1986 crop breeding programs were evaluated. These experimental wheats were crossed to develop resistance to snowmold, 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 64% (568) were scored as promising to meet the overall quality of their market classes.

In cooperation with a grant from the PNW Grains Council the milling and baking evaluations were made on commercial composites from the 1987 harvest survey representing the wheat crop of WA, OR, and ID. The data was used in their marketing brochures.

In cooperation with U. S. Wheat Associate, Inc., we again participated in a Western White Export Cargo analysis project. 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 formality.

In cooperation with the PNW Grains Council, seven advanced experimental wheat selections were pilot milled and sent to a group of collaborators for evaluations. These include four mills in Japan, two in Korea, one in The Philippines, one in Morocco, one in Egypt, and 11 local milling and baking firms.

Alternatives to Dinoseb for Weed Control in Peas and Lentils

ALEX G. OGG, JR.

USDA, Agricultural Research Service

Dinoseb has been the cornerstone of weed control programs for peas and lentils for many years. Dinoseb controls many weeds including henbit, lambsquarters, mustards, mayweed (dog fennel), nightshades, and wild buckwheat. In October 1986, the Environmental Protection Agency (EPA) issued a notice to suspend all uses of dinoseb. Through the efforts of the Dry Pea and Lentil Commission and weed scientists from Washington State University and the University of Idaho, the suspension on dinoseb was lifted for 1987 and 1988. However, it is highly unlikely that EPA will allow the use of dinoseb for weed control in peas and lentils beyond the 1988 season.

Weed research conducted by USDA-ARS in cooperation with Washington State University is focusing on finding suitable alternatives to dinoseb for weed control in peas and lentils. This research includes preplant, postplant-incorporated, preemergence, and postemergence applications of various registered and experimental herbicides applied alone or in combinations.

Results of this research will be discussed and will be shown to participants of the Palouse Conservation Field Station tour on June 30, 1988.

Bacteria Inhibitory to Winter Wheat and Weeds

A. C. Kennedy and L. F. Elliott

Bacteria inhibitory to plant growth are found on root surfaces. These bacteria, from the group pseudomonads, inhibit plants by the production of a toxin. Inhibitory pseudomonads have been found in high numbers on roots especially during the cool wet weather of late fall and early spring. These bacteria aggressively colonize the roots of different plant species, but inhibit only specific plant groups. Inhibitory pseudomonads differ from pathogens in that they do not invade the root and they do not cause lesions. It is difficult to detect these organisms in the field because there are no visible signs of pathogenicity and the toxin is usually produced only during the late fall or early spring. We are studying two groups of inhibitory pseudomonads: those that inhibit winter wheat and those that inhibit downy brome.

Winter Wheat Inhibitory Bacteria

Winter wheat inhibitory bacteria may represent a hidden yield constraint in winter wheat production. These organisms cause overwinter stand loss, poor wheat growth and yield reduction. In the spring, as much as 90% of the pseudomonads isolated from wheat roots are inhibitory. Control of these inhibitory bacteria is possible with crop rotation. Another possible control method being studied is the addition of pseudomonads that are similar to the inhibitory organisms except that no toxin is produced. These pseudomonads that do not produce toxin have the potential to be used as biological control to replace the inhibitory bacteria. Research also focuses on the factors involved in the colonization of plant roots by these inhibitory organisms.

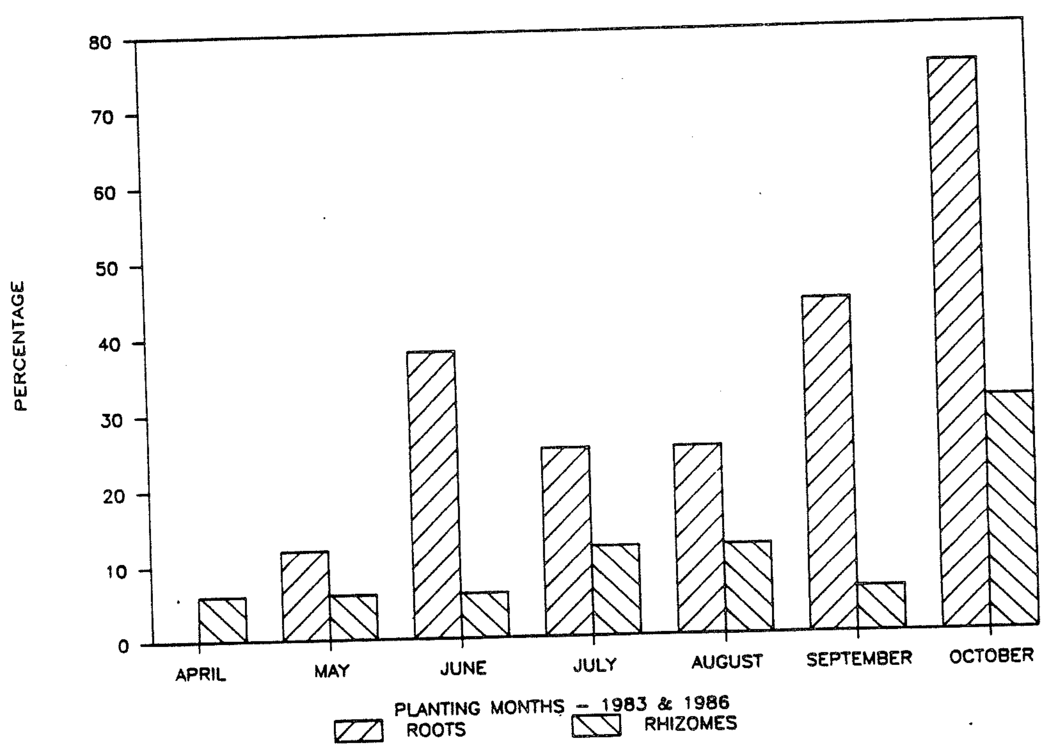
Weed Inhibitory Bacteria

Downy brome, a winter annual grass weed, is a severe weed problem in the cereal growing region of the Pacific Northwest. Downy brome gains its competitive advantage from root growth during the cold temperatures of early spring. Presently no herbicide consistently provides selective control of downy brome in cereal crops. The development of other means of control of this weed is imperative. Naturally occurring plant inhibitory pseudomonads have the potential to be used as biological control agents to control weeds. We have isolated pseudomonads that inhibit downy brome by the production of a toxin which is specific for downy brome and related weeds, but does not affect the growth of the crop. These inhibitory organisms are most effective at reducing downy brome growth at low temperatures found in late fall and early spring. Reduction in this early root growth of downy brome allows the cereal crop to compete more effectively for moisture, nutrients and space, thus reducing the negative impact of the weed on crop yield. Growth chamber and field studies have shown a reduction in downy brome stand and growth with the application of these organisms. The number of inhibitory organisms applied to a field declines during the hot dry weather of summer which means yearly application of control organisms will be necessary. This lack of survival over the summer reduces the environmental impact of the addition of this introduced organism. Field and laboratory studies are continuing to evaluate application of these bacteria as an effective method to control downy brome.

Regeneration of Field Bindweed (morning glory) Fragments

Dean G. Swan

Freshly harvested field bindweed (Convolvulus arvensis) roots and rhizomes were cut into 6-cm segments and planted, in the field, each month from April through October for two growing seasons. Results showed that root fragments regenerated and established better than rhizome fragments. The highest percentage of fragments that established was in the fall plantings and the least percentage established was in the spring plantings (see Figure). Twelve percent of the root fragments regenerated and established in the April-May plantings and 56% in the September-October plantings. Twelve percent of the rhizome fragments regenerated and established in the April-May plantings and 18% in the September-October plantings. The percentage regeneration and establishment, from the June through August plantings, ranged in between the other two planting periods. These results show that growers, in cultivating and moving cut pieces of field bindweed around the field, are likely to be starting new infestations.



Average percentage field bindweed root and rhizome fragments regeneration and establishment from seven planting dates in 1983 and 1986.

BASICS OF SUCCESSFULLY ESTABLISHING GRASS SEEDINGS FOR CONSERVATION

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

Grass/legume seeding is not nearly as difficult as some people may think. In my opinion, there are four most important points one needs to know and implement for successful stand establishment.

FOUR STEPS TO SUCCESSFUL GRASS/LEGUME SEEDINGS

1. Determine what species to seed. The species must be adapted to the site.

2. Determine the seeding rate. Pure live seeds per lineal foot. (PLS/LF).

3. Determine the time of year to make the seeding--generally this will be either spring or fall.

4. The seed must be planted shallow. For most grass/legume species, not more than 1/4 inch deep.

RUNOFF AND EROSION PREDICTION

D. K. McCool, K. E. Saxton, and R. I. Papendick

USDA-Agricultural Research Service

Much of the emphasis of this project during the past year has been placed on improving erosion prediction estimates for a national revision of the Universal Soil Loss Equation. This effort involves improving relationships for all factors in the USLE, including the influence of climate, soil, topography, crop management, and conservation practices. This is extremely important because of the cross-compliance provisions of the 1985 farm bill. Relationships in the revised soil loss equation will be applicable to the entire U.S., including the frozen and thawing soil areas of the Pacific Northwest. The USLE revision will appear in both a handbook form with tables and charts for all relationships as well as a completely computerized version. It is expected that the USLE will be a valuable tool in farm planning in the U.S. for the next 10 to 15 years, and in use internationally for a much longer time.

A simple photographic technique has proven effective for determining the percent of the soil surface covered by crop residue and growing cover. The technique is quick and simple and may be used by farmers or SCS personnel to document the residue and plant cover before the critical winter erosion season. This permanent record may be important to farmers documenting their efforts to meet cross-compliance provisions of the 1985 farm bill.

SOIL FERTILITY MANAGEMENT FOR CROP PRODUCTION IN EASTERN WASHINGTON

F. E. Koehler 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.

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 in two years of trials. Molybdenum as a seed treatment is generally recommended for each crop on Palouse and Athena type soils. Sulfur is also recommended, 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.

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.

ALTERNATIVE CROP ROTATION FOR CONSERVATION TILLAGE

W.L. Pan, S. E. Ullrich, J.L. Smith, D.R. Huggins, B. Tillman

Rotation concepts

Efforts to adapt conventional, annual crop rotations (winter wheat followed by spring peas, lentils or small grain) into sustainable no-till cropping systems have encountered difficulties with: 1) weed and disease control, and 2) spring crop establishment in heavy winter wheat residues. Early spring crop development is often unsatisfactory and has been attributed to poor seed-bed conditions created by large amounts of surface residues. Adverse conditions for spring crop establishment include poor seed placement and soil-seed contact, cool soil temperatures, excessive moisture and increased pathogens.

We are examining rotation options designed specifically for no-till cropping systems that will potentially minimize adverse weed, disease and seedbed conditions while maintaining high economic productivity. The rotation under investigation is as follows:

Winter wheat - winter legume - spring small grain

The three year rotation has several important features including:

1) an emphasis on winter crop production with higher yield potentials,
2) inclusion of a winter legume and a spring grain that will minimize weed and disease problems and facilitate control measures,
3) the management of crop residues resulting in beneficial impacts to the subsequent crop while minimizing potential adverse effects,
4) the control of soil erosion that helps ensure the long term productivity of the land.

By following winter wheat with a winter legume instead of a spring crop, the large amounts of wheat stubble becomes an asset rather than a liability by providing a protective microenvironment for seedling growth during fall and winter months. This contrasts with the often experienced detrimental effects of winter wheat residue upon the establishment and growth of a spring crop. The winter legume crop leaves behind relatively low amounts of residue that provide a better environment for spring crop establishment. The stubble from the spring crop would provide a medium level of surface residues, again benefiting the winter survival of the following winter wheat crop. The inclusion of a winter legume that can be harvested for seed provides a low input cash crop or, alternatively, could be used as a green manure to increase organic matter and N inputs into the soil.

Winter legumes

Austrian winter peas (cv. Glacier) were used as a model crop for winter seed legumes to investigate the effects of stubble management, and P and K fertility on winter survivability and yield. The plots were established near Troy, ID on a Southwick silt loam and seeded with a Lilliston double disk no-till drill on Sept. 8, 1986. Residue management treatments included i) standing stubble from the previous winter wheat crop, ii) stubble removed, and iii) stubble incorporated with a moldboard plow followed by disking. Residue management greatly affected seedling winter damage and winter survivability. Winter damage ratings are shown in Fig. 1 (D. Huggins, unpublished results). Visible leaf injury was markedly reduced under no-till for both standing stubble and stubble removed treatments in comparison to plants grown in conventionally-tilled soil. However, even though plants were more damaged in the conventional system there was 15% greater winter survival in the tilled plots. Furthur investigations are needed to identify mechanisms governing leaf damage and winter survivability. Grain yields were markedly increased by no-till management with yields averaging 2963 and 3036 lb/ac in standing stubble and stubble removed plots, respectively, compared to an average yield of 2261 lb/ac for the conventionally tilled plots. Fertilizer treatments did not have any dramatic effect upon winter damage, survivability or yield. Future research will continue to focus on seedling development, winter survival and yield of both winter peas and lentils in no-till and conventional tillage systems following a winter wheat crop.

<u>Hard red spring wheat</u>

A fertility x tillage experiment was conducted on hard red spring wheat (cv. WB906R) following winter wheat in 1987. The experiment was located in a 20" rainfall zone near Pullman, WA. An N x S factorial experiment was established under tilled and no-tilled conditions. N rates ranged from 0 to 150 lb N/A as NH_4NO_3, and S rates ranged from 0 to 45 lb S/A as $CaSO_4$ (D. Huggins, unpublished results). In general, yields under no-till averaged 25% lower than yields under conventional tillage (Fig. 2). A breakdown of the components of yield indicate that single kernel weight and kernel number/head were similar for the two tillage regimes (Figs. 3 and 4). However, the number of heads per square meter were considerably less under the no-till system (Fig. 5). A further breakdown of this component indicates that the number of heads per plant and the number of plants per square meter were reduced under the no-till system (Fig. 6 and 7). These results indicate that stress incurred during stand establishment and early crop development (tillering) adversely affected yield in the no-till system.

Protein yield (lbs N/A) was also greater under the conventional tillage system (Fig. 8), however, percent protein was consistently higher for the no-till plots (Fig. 9). This indicates that protein yield is less sensitive than grain yield to different tillage regimes and results in higher grain protein percentages under no-till systems when grain yields are reduced. It is interesting to note that both yield and percent protein responses to N applications did not plateau, but showed increases up to the highest N rate.

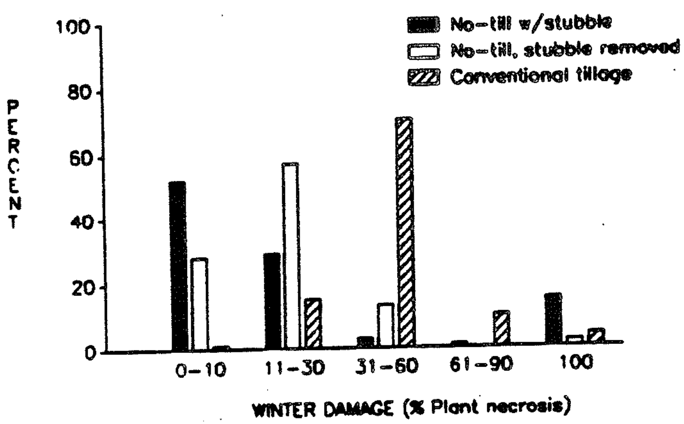
Future experiments will further evaluate the N and S requirements for hard red spring wheat as well as explore the feasibility of split fall and spring applications of N to increase grain yield and percent protein. In conventional rotations hard red spring wheat would most likely follow a winter wheat crop. However, if the no-till system previously described is utilized, increases in grain yield and percent protein of a hard red spring wheat crop may be realized if it is planted into a low residue crop such as a winter legume versus large amounts of winter wheat residue. Experiments are presently being conducted to evaluate this hypothesis.

Spring barley

Nordic and domestic genotypes of spring barley were evaluated for N use efficiency, agronomic and malting characteristics when grown under no-till conditions. We hypothesized that genotypes developed under cold, wet conditions of Scandanavian countries would be adaptable to soil conditions imposed in no-till systems. Some of the 1987 results are presented in Table 1 (B. Tillman, unpublished results). The overall yields obtained under no-till were higher than those obtained in 1986, but the genotypic rankings were somewhat similar between years. The malt barley from Denmark (cv. Nordal) ranked highest in grain yield in both years, while exhibiting high test weight and plumpness, and moderate grain protein. However, the high yielding characteristic of this genotype was not associated with unusually high rates of seedling growth during the cold conditions of early spring, nor did it exhibit a propensity to absorb high levels of N. The domestic genotypes ranked next highest in grain yield as in 1986, followed by genotypes from Sweden and Finland. Thus, genotypic comparisons of grain characteristics imply that the genoptypes developed in the northwestern United States may be equally or better adaptable to the no-till environment as these Nordic genotypes. Environmental conditions other than soil conditions likely play a major role in the overall performance of these genotypes. Since we have observed that emergence and early seedling growth is generally faster in the Nordic genotypes, these traits could be useful if incorporated into barley cultivars designed for production under conservation tillage.

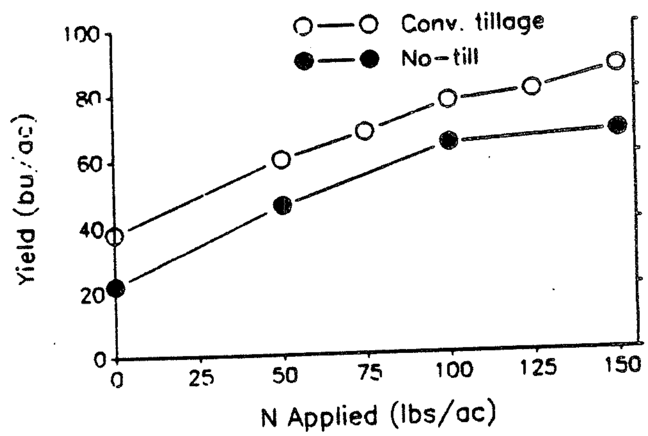
Fig. 1

AUSTRIAN WINTER PEAS (cv. Glacier)
(Troy, ID, 1986-87)



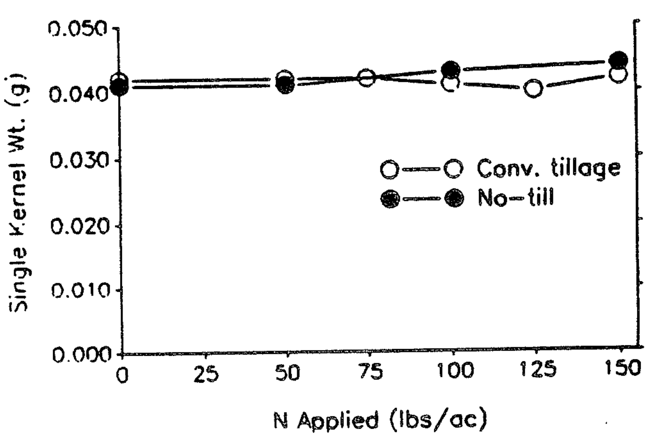
HARD RED SPRING WHEAT (cv. 906R)

Fig. 2



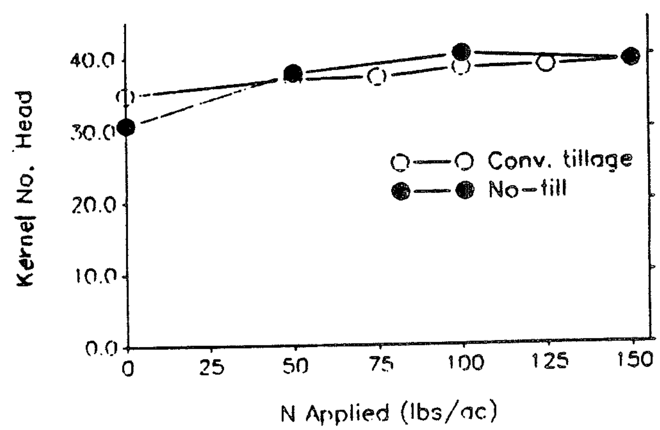
HARD RED SPRING WHEAT (cv. 906R)

Fig. 3



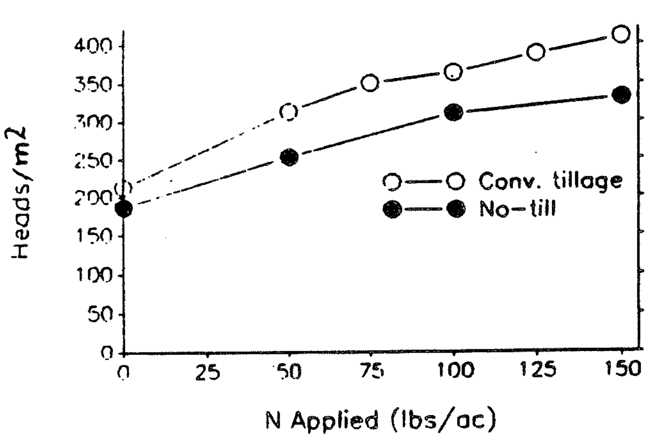
HARD RED SPRING WHEAT (cv. 906R)

Fig. 4



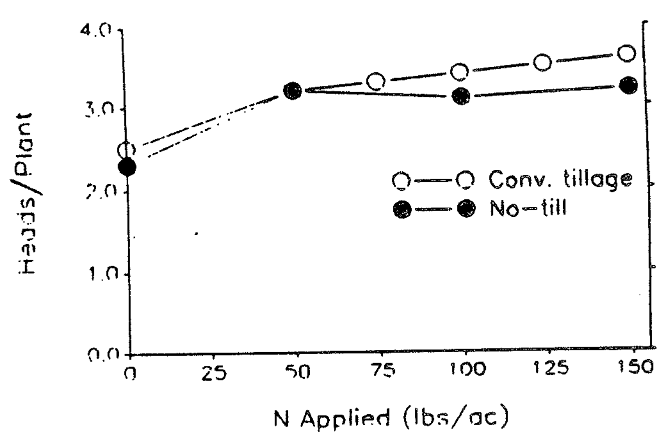
HARD RED SPRING WHEAT (cv. 906R)

Fig. 5

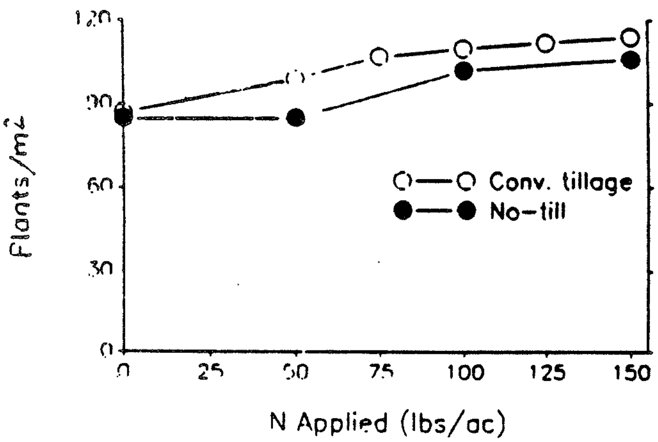


HARD RED SPRING WHEAT (cv. 906R)

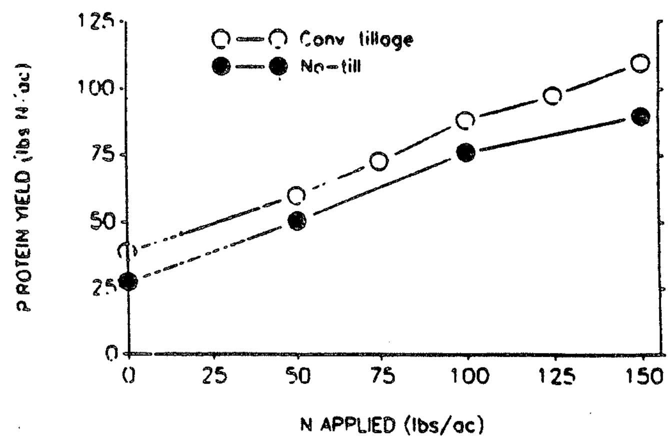
Fig. 6



HARD RED SPRING WHEAT (cv 906R) Fig. 7



HARD RED SPRING WHEAT (cv. 906R) Fig 8



HARD RED SPRING WHEAT (cv. 906R) Fig. 9

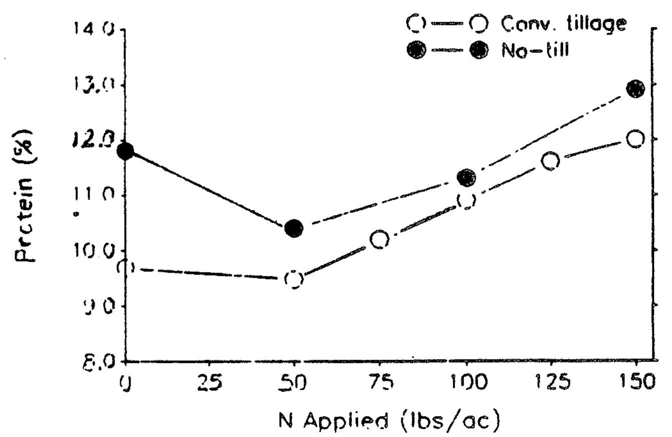


Table 1. Mean values of various agronomic factors.

Genotype	Malt/ Feed	Row Type	Grain Protein	Test Weight	Plump	Yield
			%	lb bu^{-1}	%	bu A^{-1}
Nordal (D)+	M	2	10.9^{bc*}	53.3^{a}	91.7^{a}	91.0^{a}
Steptoe (U)	F	6	9.7^{d}	49.4^{d}	91.0^{a}	88.7^{ab}
Cougbar (U)	M	6	10.1^{d}	49.6^{d}	76.4^{c}	88.7^{ab}
Clark (U)	M	2	11.7^{b}	52.9^{ab}	90.1^{a}	84.4^{a-c}
Andre (U)	M	2	11.5^{bc}	53.1^{a}	85.7^{ab}	81.2^{bc}
Pernilla (S)	M/F	2	11.6^{b}	52.3^{b}	85.7^{ab}	80.8^{bc}
BJA 80201 (F)	M/F	2	12.4^{a}	51.2^{c}	79.3^{bc}	80.1^{bc}
Agneta (S)	M/F	6	11.3^{bc}	48.5^{e}	73.4^{c}	78.7^{c}
BJA 78003 (F)	M/F	6	11.0^{bc}	46.3^{g}	38.6^{d}	78.2^{c}
Gunilla (S)	M/F	2	12.9^{a}	51.6^{c}	81.1^{bc}	77.1^{cd}
BJA Potra (F)	M	6	10.8^{c}	47.2^{f}	73.5^{c}	69.6^{d}

+ D = Denmark; F = Finland; S = Sweden; U = USA;
* Values, within the same column, having the same letter are not significantly different at P = 0.05 for LSD.

CONTRIBUTORS IN SUPPORT OF RESEARCH
1987-88
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 Co.

Herbicides

American Cyanamide
Ciba-Geigy Corp.
Hoechst-Roussell Agri. Vet.
Monsanto Co.
Rohm & Hass Co.
Union Carbide Corp.
BASF Wyandotte Corp.
Dow Chemical Corp.
ICI American
PPG Industrial, Inc.
Stauffer Chemical Co.
Vertac Chem. Corp.
Chevron Chem. Corp.
E. I. DuPont De Nemours & Co.
Mobay Chemical Corp.
Rhone-Poulenc Inc.
Sandoz Crop Protection Corp.

Cash Contributions

Cyanamide
Dow Chemical Corp.
Monsanto Co.
Stauffer Chemical Co.
Washington Wheat Commission
Western Plant Breeders
Gustafson
Triazone Inc.
Far West Fertilizer Assn.
Chevron Chem. Corp.
Hoechst-Roussell Agri. Vet.
Rhone-Poulenc Inc.
Union Carbide Corp.
O. A. Vogel Fund
Grant Co. Crop Improvement
Janssen
Great Plains Seeds
E.I. DuPont De Nemours & Co.
Mobay Chemical Corp.
Sandoz Crop Protection Corp.
Washington Barley Commission
WA Dry Pea & Lentil Co.
Maxell Hybrids
American Colloid
Uniroyal Leffingwell

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

Adams Co. Wheat Growers
American Malting Barley
Lind Grange
McGregor Company
NuChem Ltd.
Palouse Conservation District
Palouse-Rock Lake Conservation District
Puregro Co. (Ritzville, Harrington, and and Wilbur)
Whitman Conservation District
Whitman Co. Wheat Growers
Wilbur Ellis
Wilfac

Farmer Cooperators

Name	Location	Name	Location
Gene Aune	LaCrosse	Dean Kinzer	Pullman
Lynn Ausman	Asotin	Koller Farms	Mayview
Joe Babbit	Pullman	Robert Kramer	Harrington
Dale Bauermeister	Connell	Oscar Kranzler	Ritzville
Wayne Beale	Pomeroy	Jerry Krause	Creston
Bruce Beeson	Palouse	Dick Kriebel	Garfield
Bud Benedict	Asotin	Quentin Landreth	Espanola
Ken Berry	Endicott	Dick/Phil Largent	Colfax
Blankenship Farms	Washtucna	Harvey Lehmitz	Endicott
Kurt Blume	Genesee	Bob Lux	Walla Walla
Dan Boone	Pullman	Steve Mader	Pullman
Ray Brandon	LaCrosse	Keith Mader	Palouse
Brayton Land Co.	Dayton	Fred Mader	Colfax
Malcolm Brown	Garfield	Bob/Brad Marlow	Rockford
Marvin Carstens	Rearden	McIntosh Farms	Lewiston
Ed Chratal	Touchet	McGregor Farms	Hooper
Girard Clark	Pullman	McGregor Farms	LaCrosse
Jim Cochran	Palouse	Bob McKiernan	Pullman
Don Cornwall	Rockford	Barry Meacham	Pomeroy
Louis Cosner	Goldendale	Pat/Don Meiner	Walla Walla
Don Crisp	Pullman	Mielke Farms	Harrington
Earl Crowe	Farmington	Mac Mills	St. John
Van Deffenbaugh	Kennewick	Don/Steve Moore	Dusty
Dale Dietrich/Wilke Farm	Davenport	Tedd Nealy	Endicott
Dan Doty	Colfax	John Ochs	Dusty
Roger Dye	Pomeroy	Donald Ogle	Waterville
Randy Emtmann	Rockford	Gary Osborn	Troy
James Ferrel	Walla Walla	Don Quist	Palouse
Francis Fitzgerald	Clarkston	John Robinson	Pomeroy
Foundation Farms	Waitsburg	Luther/Mike Roecks	Fairfield
Bob Frazier	Walla Walla	John Scholmer	Winona
Grote Farms	Eureka	Harold Schultheis	Colton
Les Guske	LaCrosse	Tom Schultz	Reardan
Hansen Farm	Clarkston	Harvey Schumacher	Lewiston
Dave/Merle Harlow	Pullman	Jim Scott	Pomeroy
Max Hathway	Garfield	Dave Scott	Spokane
Norman Heitstuman	Uniontown	Darell Storment	Endicott
Quinten Hellinger	Potlatch	Elmo/Larry/ Jerry Tanneberg	Coulee City
Curt Hennings	Endicott	Merle/Bob Thiessen	Lewiston
Vince Hensel	Palouse	Wilford/Eric Thorn	Dayton
Ed/Henry Hiller	Pomeroy	Tig Ranch	Lind
Hoffman Farms	Clyde	Tony Viebrock	Waterville
Cecil Howard	Palouse	Bob Walli	Ralston
Lowell Huffman	Lenore	Don/John Wellsandt	Ritzville
Cleater Hughes	Endicott	Lyle West	Palouse
Tom Hyslop	Espanola	Curt White & Sons	Lamont
Albert Jacobson	Waterville	Jon Whitman	Pullman
Larry Johnson	Mt. Vernon	Mike Whitman	Pullman
Dwelly Jones	Walla Walla	Paul Williams	Reardan
Dick Juris	Dayton	Joe Wolf	Clarkston
Ron Juris	Bickleton		
Charles Keno	Fairfield		

COOPERATIVE PERSONNEL AND AREA OF ACTIVITY

Samuel Smith......................President, Washington State University
J. L. Ozbun................Dean, College of Agriculture & Home Economics
L. F. Rogers............................Director of Resident Instruction
J. J. Zuiches..Director of Research, College of Agriculture & Home Econ.
F. L. Poston..........................Director of Cooperative Extension
D. G. Miller............................Chairman of Agronomy and Soils

Cereal Breeding, Genetics, and Physiology

R.E.Allan, J. A. Pritchett, L. M. Little, USDA, ...Wheat Genetics
E. Donaldson, M. Nagamitsu, B. Sauer, Dry Land Research Unit Lind..Wheat
C. F. Konzak, M. A. Davis, ...Wheat Breeding & Genetics
S. E. Ullrich, C. E. Muir, D. A. Deerkop......Barley Breeding & Genetics
C. J. Peterson, D. F. Moser, K. Hinnekamp.................Wheat Breeding
R. L. Warner, A. Kleinhofs..................Cereal Evaluation Laboratory
S. E. Brauen, Puyallup...................................Varietal Testing
B. C. Miller, P. E. Reisenauer, Pullman.................Varietal Testing
M. K. Walker-Simmons, J. Sesing-Lenz..................Cereal Physiology

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

G. L. Rubenthaler.....................Research Cereal Chemist in Charge
H. C. Jeffers.......................................Research Technologist
P.D. Anderson, A.D. Bettge, D.Engle.........Physical Science Technicians
G.E. King.......................................Early Generation Testing

Cereal Diseases

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

Breeding and Culture of Dry Peas and Lentils

F. J. Muehlbauer, J. L. Coker, R. Short, & S. Spaeth, USDA

Weed Control

A. G. Ogg, F. L. Young, and D. R. Gealy, USDA
D. G. Swan, T. L. Nagle, and H. H. Cheng

Fertility and Management

F. E. Koehler, W. L. Pan, E. T. Field, C. F. Engle
R. I. Papendick, L. F. Elliott, D. McCool, and K. Saxton, USDA

Cereal Crop Seed Increase

T. D. Wagner

USDA Plant Material Center

Clarence Kelly, Manager

Spillman Farm Manager

Ray Nelson

Dry Land Research Unit Farm Manager

Dick Hoffman

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

Dry Pea Production, EB0582
Growing Lentils in Washington, EB0590
Garfield and Tracer Alaska Type Peas, EB0699
Tekoa Lentil Culture, EC0375
Pea Leaf Weevil: Biology and Control, EM3477
Peas, Lentils for EAstern Washington, FG0025
Insects of Peas, PNW0150
Seed Rates and Phosphorus Placement for Alaska Peas in the Palouse, XB0794
Seed Rates Tekoa Lentils, XC0565
Diseases of Cereal Crops, EB0559
Insect Control in Stored Grain and Peas and Seed Treatment for Small Grains, EM3314
Winter Wheat and Barley for Western Washington, FG0017
Spring Wheat, Barley and Oats for Western Washington, FG0048
Wheat and Barley Output Under Alternative Prices in Washington and North Idaho, XT0061
Boyer Winter Barley, EB0678
Blazer Spring Malting Barley, EB0679
Advance Barley, EB0720
Vanguard Barley, EC0385
Steptoe Barley, EC0392
Barley for Eastern Washington, FG0029
Effect Seed Time/Spring Barley, WC0476
Steptoe Barley, XC0572
Morphology/Himalaya Barley, XT0055
Cayuse Oats, EC0358
Western Washington Weed Control Guides Green Peas, EM3342
Biology and Control of the Pea Weevil, EM4004
Peas for Western Washington, FG0027
Irrigated Peas for Central Washington, FG0033
Economics of Pea Harvest Methods in Eastern Washington and Oregon, XB0684
Fertilizer Placement/Peas, XB0721
Acidity and Phosphorus/Peas, XB0722
Pea Varieties/Freeze Can, XC0483
Pea Varieties/Freeze Can, SC0503
Fertilizer Experiments/Irrigated Peas, XC0547
N Fertilizer/Irrigated Green Peas, XC0566
Forecasting Crop Yield and Income in the Palouse Wheat Pea Area, XB0712
Financial Structure of Large Farms in the Washington Wheat-Pea Area, XB0738
Irrigated Small Grains, Central Washington, FG0009
Winter Wheat and Barley for Western Washington, FG0017
Spring Wheat, Barley and Oats for Western Washington, FG0048
Wheat and Barley Output Under Alternative Prices in Washington and Northern Idaho, XT0061

Annual Weed Control in Winter Wheat, EB0599
Daws Wheat, EB0676
Barbee Wheat, EB0677
Urquie Spring Wheat, EB0682
Wanser and McCall-Hard Red Winter Wheats, EC0355
Luke Wheat, EC0378
Paha Wheat, EC0379
Sprague Wheat, EC0390
Wared Spring Wheat, EC0396
Frost Damage on Wheat, EC0398
Lewjain Winter Wheat, EB1168
Description and Culture of Chickpeas, EB1112
Lower Granite Dam & Waterway User Charge Impact on PNW Wheat Movement, XB0887
Economics of On-The-Farm Grain Storage, XC0473
Effect Seed Time/Spring Barley, XC0476
Greenbug in Washington, XC0553
Operating Costs for Tillage Implements on Eastern Washington Grain Farms, XC0554
Steptoe Barley, XC0572
Waverly Spring Wheat, EB1256
Andre Spring Barley, EB1249
Crew Winter Wheat, EB1212
Irrigated Spring Wheat Production in Washington, EB1111
Irrigated Winter Wheat Production in Washington, EB00916
Wheat Seed Quality, EB1256
Spring Barley, EB1260
Dusty Wheat, EB1381
Tres Winter Wheat, EB1463
Cougbar, EB1476
Penawawa Spring Wheat, EB1482
Edwall Spring Wheat, EB1483