FIELD DAY

Dry Land Research Unit

Lind, Washington

June 25, 1970

INTRODUCTION

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

Adams County has played an important part in the history of the station. The county donated $6000 to start the station and the land has been donated by the county. In the early 30's during the depression, Adams County kept the station alive with a small appropriation until the College could fund the operation again. In 1965 the land was deeded to Washington State University for as long as it is used for experimental purposes.

The first superintendent was the late Dr. M. A. McCall. Dr. McCall was a gifted researcher given somewhat to philosophy in his early reports. In a 1920 report, he outlined the fundamental reasons for an outlying experiment station. He stated, "A branch station, from the standpoint of efficiency of administration and use of equipment, is justified only by existency of certain problems, which, because of special conditions such as climate, soil, etc., cannot be studied at a central station." For over fifty years this station has followed this policy of studying the problems associated with the 8 to 12 inches 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. Although the name has changed, the station still is devoted to dry land research. This experiment station has the lowest rainfall of any research station devoted to dry land research in the United States.

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

The major portion of the research has centered around wheat. Variety adaption, wheat production management including weed and disease control, and wheat breeding are the major programs of research in recent years. 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 54th field day. Visitors are welcome at any time. Their suggestions are appreciated.

CLIMATIC DATA

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

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

Month	Temperatue °F.		Precipitation		Precipitation
	Max.	Min.	1969	1970	49 yr. av. (in.)
January	34	22	1.25	2.89	1.01
February	42	24	.68	1.27	.90
March	53	32	.29	.74	.71
April	63	35	1.37	1.07	.63
May	72	42	1.17	.46	.76
June	83	45	.26		.94
July	90	52	.00		.21
August	90	50	.00		.31
September	79	45	.43		.55
October	65	38	.28		.93
November	47	29	.32		1.23
December	37	26	1.55		1.25
					9.43

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.

RESEARCH ON CEREAL CROPS

The objective od the Dry Land Research Unit cereal breeding and testing program is to develop new varieties of cereals adapted to the Big Bend area, where annual rainfall is less than 13 inches. The program includes testing new varieties, and selections developed at other experiment stations throughout the Midwest and Pacific Northwest, foreign breeding programs, and breeding new varieties. Actual breeding and selection are done at the Station.

Final testing is at selected locations in the Big Bend. These sites are now located on the Bill Schmidtman farm, Waterville; Robert Kramer farm, Harrington; and Vollmer and Bayne farm, Horse Heaven Hills.

All experimental work at the outlying locations is conducted by the same methods as the work at the Station. About sixty varieties and new selections from breeding nurseries are tested at these locations. Farmers in these areas are urged to visit the plots on county tours or at any other time. The results of these trials and those at the Dry Land Research Unit will determine the value of any new selection for the Big Bend Area.

WHEAT BREEDING

Winter Wheat Breeding At The Dry Land Research Unit

W. L. Nelson, M. Nagamitsu

The major emphasis in wheat breeding at the Dry Land Research Unit is on hard red winter wheat. This program is planned to develop varieties adapted to the area which can produce hard red wheat and will include most of the area of below 10 inches of annual rainfall.

The program was started in 1951 with parent evaluation and crosses were made in 1952. Since 1952 crosses are made each year to continually add new sources for yield, quality, winter hardiness and disease resistance. Many of the crosses have been between high yielding white wheat varieties and the better yielding hard red varieties to improve the yield potential of the hard reds. Disease resistance is of major concern in the program and includes crosses for stripe rust, smut, foot rot and snow mold resistance. The stripe rust screening is made during the winter months in the greenhouse section built with Wheat Commission Funds. An average of 8,000 lines are screened each year in this program. As a result of this program, highly resistant lines are now in yield test stage with thousands more in the preliminary stages of testing.

Snow mold resistance has been included in the program since 1963, and selections in the eighth generation are now in the yield test stage. Over a hundred crosses with 10 sources of snow mold resistance have been made, and the second generation crosses have been made on the most promising snow mold crosses.

Every attempt is made to include a wide genetic background in the breeding program. Different types and sources of disease resistance are used to help prevent having only one source of resistance to any given disease. Many of the sources for disease resistance, winter hardiness, quality, or yield are not well adapted to the area and require one or two series of crosses (parent building) to get the desirable features in varieties that do well under our conditions. The breeding program, then in a continuous program of attempting to get the desirable traits of the parents into adapted varieties of high quality and disease resistance for the low rainfall area.

The first two varieties to come out of this program were Wanser and McCall from the cross of Burt x Itana. These varieties have had an outstanding yield record. During the last five years these varieties were among the highest yielding in the regional tests. A summary of these yields are given in Table 2.

Wanser and McCall are widely adapted as shown by regional tests. The varieties yield well under both low and intermediate rainfall conditions. They are not recommended for rainfall areas of over 12" because the protein level is usually low. Table 3 gives the yields in the low and intermediate rainfall areas of Washington and Oregon.

Table 2. Yield of selected hard red winter varieties in the western regional hard red winter trials 1965-69.

Variety	1965 17 locations	1966 22 locations	1967 21 locations	1968 15 locations	1969 17 locations	5 yr av.	% Kharkof
Wanser	60.5	46.3	48.6	53.1	44.7	50.6	117
McCall	63.5	45.1	47.5	48.9	46.9	50.4	117
Cheyene	56.7	42.3	43.4	46.0	45.2	46.7	108
Itana	52.7	40.6	39.0	46.0	44.0	44.5	103
Kharkof	52.7	37.5	40.8	42.5	42.5	43.2	100

Table 3. Yield of selected varieties in low and intermediate rainfall areas in Washington and Oregon, 1964-69.

Variety	Lind 9.5"	Moro, Ore.* 11"	Pomeroy 14"	Pendleton 14"	Average
	Location and Rainfall				
Nugaines	39.2	28.8	65.1	68.3	50.4
Gaines	40.4	32.2	67.1	68.7	52.1
C59287/ 101-66437**	35.9	---	56.7	---	46.3
Burt	36.8	30.4	52.3	58.8	44.6
Suwon 92/4* Burt-6528**	30.0	25.6	51.5	63.5	42.7
Moro	39.4	30.9	56.8	58.6	46.4
Omar	35.0	28.9	53.2	53.2	42.6
Suwon 92/4* Omar-6510**	32.4	22.9	60.3	68.5	46.0
Wanser	37.3	32.7	54.8	61.3	46.5
McCall	37.8	30.4	55.1	61.4	46.2
Cheyenne	36.1	30.3	54.3	54.1	43.7
Kharkof	33.6	25.5	49.5	49.6	39.6
Station Average	36.2	29.0	56.4	60.5	45.5

*Moro location 5 years-1965 missing
**1968 and 1969 data

McCall and Wanser are adapted to areas now growing hard red winter or in the pacific Northwest. Due to price differential often paid hard red winter wheat, it may be more profitable to grow these varieties in some areas now producing white wheat.

Both varieties have good bread quality at protein levels of 11 percent or above, and are equal to any other hard red variety at lower protein blending with higher protein wheat.

In table 4, 5, and 6 the agronomic characteristics of recommended varieties, and the older varieties they replace, are given for four locations in eastern Washington. These data are from rod row nurseries. Table 7 gives the data from large scale field plots at Lind. Data from these trials' and other large scale field plots in eastern Washington are used to make variety recommendations.

For early seeding in the 8 to 11 inch rainfall area, Wanser, McCall and Moro are recommended. Wanser is recommended for Adams, Franklin, and Betnon, Grant, and Lincoln counties for those areas well adapted to hard red winter wheat. McCall is recommended for Douglas and Grant counties. In these same general areas, Moro is recommended for farmers growing club wheat for early seeding. In years when summer fallow moisture is excellent for early seeding, Nugains has the highest potential in the 10 to 11 in. rainfall area.

In areas of 11 to 13 inches in Adams, Grant, Lincoln and Douglass counties, Nugaines has the highest yield potential from either early or late seeding. When summer fallow moisture is good for early seeding, Nugaines is recommended for these areas. When summer fallow moisture is questionable or poor, Moro should be considered because of better emergency characteristics. Moro should be seeded one week to 10 days later than other varieties because of excessive fall growth.

Table 4. Yield in bushels per acre and percent of Kharkof for winter wheat varieties at two locations in rod row plots.

	HARRINGTON 1252-68			HORSE HEAVEN 1951-67		
Variety	No. years grown	% Kharkof	Av. yield bu/a	No. years grown	% Kharkof	Av. yield bu/a
Gaines	8	141	46.9	5	111	19.1
Nugaines	4	146	41.5	---	---	---
Burt	16	124	44.8	9	115	21.2
Moro	4	135	38.2	2	121	15.3
Omar	11	117	41.1	8	115	20.9
Wanser	2	150	33.4	3	117	17.8
McCall	2	158	35.2	3	113	17.1
Cheyenne	--	---	---	8	114	20.2
Kharkof	16	100	36.2	10	100	18.3

Table 5. Summary of agronomic characteristics of winter wheat grown at Lind in rod row nurseries, 1952-69.

Variety	Plant ht.	Test wt.	1969 yield bu/a	Average yield bu/a	Yield % Kharkof	No. Years grown
Nugaines	25	62.6	21.8	39.2	121	5
Gaines	26	60.7	23.7	42.6	127	10
C59287/101-66437	23	60.8	26.2	35.9	132	2
Burt	29	61.1	20.2	35.8	117	15
Suwon 92/4* Burt-6528	22	62.6	18.1	30.0	110	2
Moro	28	59.2	18.3	39.4	117	6
Omar	30	59.4	20.2	34.8	108	12
Suwon 92/4* Omar-6510	22	60.0	21.6	32.4	119	2
Wanser	29	62.5	20.1	37.3	111	6
McCall	29	62.8	25.5	37.8	113	6
Cheyenne	32	61.6	23.3	36.4	113	12
Kharkof	32	60.7	18.4	30.5	100	15

In areas above 13 inches, Nugains is recommended for either early or late seeding. Good summer fallow management in this rainfall area increases the probability of holding moisture adequate for early seeding. Use year old seed of Nugaines for early seeding whenever possible to avoid high temperature dormancy often found in Nugaines. New seed should be checked for high temperature dormancy when seeding into soils with temperatures in excess of 70°.

The only varieties that are recommended for eastern Washington are Nugaines, Moro, Wanser, and McCall. If in doubt about the variety to seed in your immediate area and soil condition, see your County Agent.

Table 6. Summary of agronomic characteristics of winter wheat varieties grown near Waterville in rod row nurseries, 1952-69.

Variety	Plant ht.	Test wt.	1969 yield bu/a	Average yield bu/a	Yield % Kharkof	No. Years grown
Nugaines	26	63.2	36.6	51.5	139	4
Gaines	26	61.6	34.2	50.3	135	8
C59287/101-66437	23	62.7	38.8	38.8	174	1
Burt	31	61.6	25.9	40.2	118	13
Suwon 92/4* Burt-6528	24	63.4	28.3	35.2	114	2
Moro	32	60.2	37.8	44.9	121	4
Omar	32	60.0	39.8	41.0	120	12
Suwon 92/4* Omar-6510	24	61.5	37.6	41.1	134	2
Wanser	34	62.9	29.1	45.2	124	5
McCall	33	63.0	32.7	44.6	120	4
Cheyenne	36	62.1	25.7	40.8	115	10
Kharkof	37	61.7	22.3	33.8	100	14

Table 7. Summary of agronomic data for winter wheat varieties grown at the Dry Land Research Unit in drill strip plots, 1954-68.

Variety	Date head	Plant ht.	Winter* hardi-ness	Stripe* Rust	Av yield bu/a	Yield % Kharkof	Test wt	No. years grown
Gaines	5/31	24	5	4	40.4	122	61.1	9
Nugaines	5/30	25	5	3	36.3	122	61.6	4
Burt	5/29	29	4	6	35.4	115	61.0	14
Moro	5/30	29	6	1	38.7	130	58.6	4
Omar	6/3	30	6	8	36.1	115	59.3	12
Wanser	5/28	29	2	3	37.0	117	62.0	6
McCall	5/29	28	3	5	36.6	120	62.3	5
Cheyenne	5/29	32	1	4	34.7	111	61.6	12
Itana	5/29	33	2	8	33.2	107	61.8	13
Kharkof	5/30	33	1	4	30.9	100	60.6	14

*Coded to 1 to 9 scale, with 1 most hardy or resistant and 9 least hardy or resistant.

NEW VARIETIES BEING CONSIDERED FOR RELEASE

Kenneth J. Morrison
Extension Agronomist

Suwon 92/4*Burt-6528, CI- 14483, is a semi-dwarf Burt type hard white wheat selection made at Pullman. It is very similar to Burt in general appearance, winter and spring growth habits, winter-hardiness, kernel type and milling and baking qualities. The selection has shorter straw than Burt. It is slightly more tolerant to Cercosporella footrot than Burt. The germination and emergence characteristics are very similar to Burt, representing an improvement over Nugaines and other relatively slow-emerging, semi-dwarf varieties. It is superior to Burt in resistance to stripe rust, lodging, and shattering.

The selection appears to be worthy of release in Washington for the production of strong gluten Burt-type hard white wheat desirable in the domestic and foreign markets. Tests indicate it is best adapted to good management in areas receiving between 10 and 14 inches of annual precipitation. When grown under relatively severe conditions of drought and severe freezing temperatures it has shown no advantage in potential yield over Wanser or Burt. The new selection will probably be named Coulee.

Suwon 92/4*Omar-6510, CI-14485, is a short, standard height, Omar type white club wheat selection made at Pullman, Washington. The selection is shorter but in other characteristics is similar to Omar in appearance, growth habit, winter-hardiness, kernel type, milling and baking qualities and in reaction to common and dwarf bunt. The high resistance to stripe rust was inherited from Suwon 92. It has moderate resistance to Cercosporella footrot. The selection is superior to Omar in resistance to lodging, shattering, but is notably more susceptible to powdery mildew and flag smut. Good germination and emergence characteristics of the selection are similar to Omar.

Compared to Moro the new selection appears better adapted to the areas which most consistently produce the quality of club wheat desired by domestic and foreign markets. Under conditions of relatively low rainfall and critical soil moisture conditions at seeding time, Moro is expected to maintain its favorable competitive position principally because of ease of stand establishment and early maturity.

The high susceptibility of the Suwon/Omar cross to dwarf and flag smut are expected to retard its widespread adoption in the intermediate rainfall area. This selection would fill the need for a low protein, high quality Omar-type club wheat highly desired in the domestic and Japanese market. If the variety is released it will be called Paha.

C59287/101-66437, VH-66437 is a soft white semi- dwarf wheat selection for use in counteracting the recent widespread appearance of new races of dwarf bunt. Parents of this selection include PI-178383 x Burt. 178383 was one of the parents of Moro. The result of this cross was then crossed with Selection 101, one of the high-yielding semi-dwarf selections. C59287/101-66437, VH-66437 is resistant to all known races of common and dwarf bunt is recently well adapted to areas where new races of dwarf bunt are found on Gaines and Nugaines. This selection is notably superior to these two varieties in resistance to Cercosporella footrot, snow mold, caused by Fusarium nivale and to stripe rust.

The winter-hardiness, growth habits and general appearance are similar to Gaines. The milling quality is unusually good for soft white wheat and the baking quality is similar to Gaines. Its resistance to loding, shattering, and leaf rust are slightly less than Gaines. This selection is also susceptible to flag smut.

This selection, if it is released, will probably be named Luke.

Spring Wheat

The spring wheat breeding program at the Dry Land Research Unit is designed to improve yield, protein content, quality, and disease resistance of adapted varieties. A comparison of Marfed, the highest yielding spring wheat, and Burt, a high yielding winter wheat, for the period of 1952-68 shows a 12 bushel yield advantage for Burt. Several years the difference exceeded 20 bushels in favor of the winter wheat. Higher yield is urgently needed for spring wheat varieties.

Spring wheat is seeded if winter wheat cannot be seeded because of lack of moisture, reseeded into winter killed wheat, and for rotation to control weeds. A higher yielding spring wheat would be very valuable in years when it is necessary to seed spring wheat. It could be used much more effectively in a rotation to clean up weed infested fields that have been continuously cropped to winter wheat. Since spring wheat is used more as an emergency crop, yield is even more important than in winter wheat.

Table 8 and 9 shows the agronomic characteristics of standard spring wheat varieties grown in the dryland region.

Marfed is the highest yielding variety at all locations.

Table 8. Summary of agronomic characteristics of spring wheat grown at Lind in rod row nurseries, 1950-69.

Variety	Date head	Plant ht.	1969 yield bu/a	Av. yield bu/a	% Baart	Test wt.	No. years grown
Marfed	6/14	25	22.5	23.9	113	58.9	19
Idaed (Idaed 59)	6/9	25	15.4	20.9	99	59.1	19
Lemhi	6/13	26	21.0	22.1	105	57.9	19
Federation	6/12	25	19.1	22.0	104	58.5	19
Henry	6/11	27	*	20.0	94	59.1	16
Adams	6/13	26	16.3	23.0	108	59.3	7
Burt/KF 58-2025	6/14	24	21.5	24.5	110	58.4	6
Baart	6/11	28	18.9	21.1	100	60.3	19

*Not grown

Table 9. Yield in bushels per acre and percent of Baart for spring wheat varieties at three locations in rod row plots.

Variety	Harrington			Waterville			Horse Heaven		
	No years grown	% Baart	Av. yield bu/a	No. years grown	% Baart	Av. yield bu/a	No. years grown	% Baart	Av. yield bu/a
Marfed	19	117	30.8	18	115	30.1	16	108	19.1
Idaed (Idaed 59)	19	114	29.9	18	102	26.7	16	100	17.7
Lemhi	19	102	26.8	18	106	27.9	16	101	18.0
Federation	19	104	27.3	18	105	27.6	16	101	17.8
Henry	17	106	28.2	16	96	25.9	15	96	17.5
Adams	6	107	27.6	6	107	26.9	5	99	13.4
Burt/KF 58-2025	6	106	26.6	6	100	25.6	5	92	12.1
Baart	19	100	26.3	18	100	26.2	16	100	17.7

The spring wheat breeding program at the Dry Land Research Unit is testing a large number of both red and white spring wheats. This program has been expanded to include both Pullman and Royal Slope locations.

Henry/Burt Sel. 65-2 is a hard red spring wheat with acceptable quality, but is susceptible to stripe rust. This selection is one of the most promising of the hard red selections. Yield data is shown in Table 10.

Table 10. Yield in bushels per acre and percent of Marfed for a hard spring wheat selection grown Lind for 7 years.

Variety	Av. yield bu/a	% Marfed
Marfed	23.5	100
Idaed	19.4	83
Henry/Burt S 65-2	22.2	96

The advanced white spring wheat selections are stripe rust resistant, good milling quality, and of the pastry type. These are high yielding selections which have consistantly out yielded Marfed.

WEED CONTROL IN WINTER WHEAT

Dean G. Swan
Extension Weed Specialist
Associate Agronomist

Chemical weed control in winter wheat has been undergoing rapid changes in the past few years. From the late 1940's until about 1964, the only selective herbicides available for annual broadleaf control in winter wheat was 2,4-D and MCPA. Now Washington State University recommends eight herbicides for broadleaf control in winter wheat. These include:

Diuron (Karmex)	2,4-D
Linuron (Lorox)	MCPA
Terbutryn (Igran)	Bromoxynil+MCPA (Bronate, Brominal+)
Bromoxynil (Brominal, Buctril)	Dicamba (Banvel) + 2,4-D

All of these materials have various restrictions concerning area use. Before a grower makes a decision concerning a new herbicide he should read Extension Bulletin 599, Annual Weed Control in Winter Wheat in Eastern Washington. Each product is discussed in the bulletin.

In the fall of 1969 an experiment was established on the Lind Station to test these materials on wheat grown under local conditions. Research results from these experiments show that growers, by choosing the right selective herbicide and with appropriate timing, can control virtually all problem broadleaf weeds in the winter wheat-producing area in eastern Washington.

Downy brome (cheatgrass) continues to be a major problem in the winter wheat-growing area. Research has and continues to be conducted in attempting to find a selective herbicide for the control of downy brome in wheat. To date these attempts have been unsuccessful but promising new herbicides appear on the market each year and the possibility of finding a selective material is good. Many compounds have been tested over the past ten or twelve years. This list includes more than 40 herbicides tested singly at varying rates and more than ten tested in combination with other herbicides. These do not include the compounds tested by other research workers. Several of these herbicides were only tested one year. They either did not control downy brome, caused crop injury, or both. Other materials were tested for several years and then dropped because of lack of performance or crop injury.

A few are presently being tested in combination. Some of the herbicides in the 1970 screening trial look promising and will continue to be tested in the hopes that they may eventually give downy brome control and crop safety that is necessary before they are suggested for grower use.

In addition to the downy brome screening work being conducted on the Dryland Experiment Station, there is also some exploratory cultivation work being conducted. Another approach, directed spraying with known grass-killing herbicides, is being studied.

WHEAT DISEASES

The most prevalent diseases in the low rainfall area are stripe rust, snow mold,and foot rot. Common and dwarf bunt, or stinking smut, are now controlled by good varietal resistance and seed treatment. Smut is always a threat and new sources of resistance are being added to new varieties. Active research on all of the diseases is conducted cooperatively with WSU plant pathologists. Major emphasis for control of these diseases is through breeding.

Stripe Rust

The potential for a serious stripe rust epidemic has been present almost every year for the past 10 years. Generally, however, it is held in check by dry weather in spring and early summer. Sometimes, as in 1960, 1961, and 1967 the disease occurs over wide areas and causes heavy loss. In other years, the disease is of only local occurrence, and losses are light. There was good overwintering of the rust fungus this year, but the chances now seem good that a major outbreak will be avoided.

The Washington Wheat Commission financed a new section of the greenhouse for the station in 1964, especially equipped for stripe rust screening. During the past four years over 24,000 plant lines have been screened for stripe rust resistance. Several new sources of stripe rust have been added to the breeding program. Rust resistance is incorporated in all of the breeding programs for the low rainfall area.

To date, chemical control of stripe rust has not been particularly effective or economical. However, a new material, Plantvax, continues to show promise and may find acceptance for use under heavy rust conditions, if and when it is released for use. Other systemic compounds are being investigated.

The most effective control of stripe rust is through resistant varieties. Of the commercial varieties, Moro is highly resistant even as seedlings, to many of the prevailing races of the stripe rust fungus. It is susceptible however, to certain other races. The distribution and overall significance of the latter races is not yet established. Nugaines, Brevor, Gaines, Wanser, Cheyenne, and McCall are recommended varieties which have mature plant resistance. McCall has less resistance than the other varieties listed. These varieties will yield quite well under stripe rust infection.

Stripe rush research is under the leadership of Dr. J. W. Hendrix, WSU Plant pathologist, and Dr. R. F. Line and R. A. Allan, ARS, USDA. The overall program includes epidemiology studies, biological race studies, evaluation for variety resistance breeding, and evaluation of chemicals for rust control.

Snow Mold

G. W. Bruehl, Dick Nagamitsu, and C. Peterson

The following survival and recovery ratings were given to varieties in the snow mold nursery in Douglas County in 1970. To be considered "snow mold resistant" a variety should score 50 or better.

Burt	1	McCall	5
Suwon 92/4*Burt-6528	1	Suwon 92/4*Omar-6510	5
Nugaines	2	Omar	11
Itana	3	Moro	34
(14x53/Odin)/CI 13431 S. 6425	3	C59287/101-66437	40

Moro, developed by Dr. C. Rohde at Pendleton, Oregon, and C59287/101-66437, developed by C. Peterson at Pullman, both derive their resistance from PI 178383. On the basis of the 1970 results, C59287/101-66437 is the most resistant variety that has ever been developed in the Pacific Northwest. It should be sufficiently resistant to perform well under light to moderately severe snow mold.

The excellent performance of our advanced lines in the snow mold nursery lead us to feel that it is possible to develop useful wheats that can survive and yield well even after severe attacks. The best advanced lines, having passed the snow mold tests, will be evaluated agronomically and increased for possible release by Dick Nagamitsu and Walt Nelson.

Mr. Barry Cunfer, a student at WSU, found that resistant wheats have higher carbohydrate reserves than susceptible wheats. A greater food supply could help wheats survive the long periods under snow and contribute to resistance.

The fungicides tried offer no help.

Root and Foot Rot Diseases
Dr. R. James Cook

Cercosporella foot rot, Fusarium foot rot, and take-all are the important foot rots of wheat in the low rainfall area of Washington. Dr. G. W. Bruehl, Department of Plant Pathology, Washington State University, and Dr. R. James Cook, Regional Cereal Disease Research Laboratory, Pullman, are project leaders in the study of these three diseases with the Dry Land Research Unit cooperating.

Of the three, Cercosporella (also known as strawbreaker) is most widespread and damaging to wheat in eastern Washington. The disease is favored by early seeding and lush fall stands. Consequently, it is increasing in importance where wheat is grown under supplemental irrigation. Tests for varietal resistance to this disease are made cooperatively by Drs. Bruehl, Vogel, and Peterson at Pullman. Results of their tests are presented in another section of this brochure.

Fusarium root and foot rot is most destructive in the drier years and in early seeded fields. Laboratory studies have now shown that this fungus grows poorly or not at all in moist soil but grows very well in dry soil, including some dust mulch soil too dry for wheat seed germination. It is becoming increasingly more clear that under dryland conditions, the management practices used to obtain maximum yields for the water available (e.g. early seeding, high fertility, use of high tillering, high yielding varieties, etc.) contributes to the severity of Fusarium foot rot. These practices may lead to premature soil-plant water stress so ideal for Fusarium. Studies are now underway in cooperation with Dr. R. I. Papendick, ARS Soil Scientist, Pullman, on how to alleviate or avoid water stress in wheat and at the same time permit maximum bushel production.

Tests for resistance to Fusarium are made in naturally infested soils and are conducted cooperatively by Drs. Vogel, Peterson, and Cook. This year's nursery is on the Robert Kramer farm south of Harrington. There is evidence that some varieties utilize available soil water more efficiently or slowly, stress more slowly, and show less damage from Fusarium.

The foot rot known as take-all and caused by Ophiobolus graminis continues to appear in the Columbia Basin in fields cropped two or three consecutive years to wheat under sprinkler irrigation in a plot in the Lind Station but, as yet, show very little take-all. This plot was started in cooperation with the Dry Land Research Unit for the purpose of testing wheats for resistance to Ophiobolus. Several hundred pounds of severely diseased (take-all) stubble were spread over the plot at the start of the experiment three years ago. Moreover, recent greenhouse tests have demonstrated considerable amounts of fungus (inoculum) in the soil but for some unknown reason this inoculum has been relatively ineffective.

Unlike Fusarium, Ophiobolus thrives in moist soil and is sharply limited in dry soil. In addition, the fungus causes greatest amount of disease when the soil is of low nitrogen fertility. With these two factors in mind, the Lind plot was not fertilized this past year but was watered approximately once per week since seeding, but still take-all has failed to develop. Tests are now underway to determine why take-all is slow to develop or may never develop in the Lind plot. Such information may provide clues for future studies on cultural control of this disease.

Avoid early seeding in fields where root and foot rot occur. This applies regardless of whether the cause is Fusarium, Cercosporella, or Ophiobolus. Where wheat is grown under supplemental irrigation, avoid recropping if possible. A wheat-wheat-wheat rotation under irrigation favors both Ophiobolus and Cercosporella whereas wheat-fallow-wheat rotation lessens the effects of these two diseases. Fusarium, on the other hand, persists in fallow soil. Oats may cause acute build-ups of Fusarium and hence should be avoided as much as possible as a crop in the dryland area. Do not side dress fertilize, rotary hoe or skew tread in the spring in Cercosporella-infested fields as this will increase damage caused by this fungus.

Straw breaker (Cercosporella) foot rot of winter wheat
G. W. Bruehl, O. A. Vogel, and C. Peterson

Large scale inoculations with the straw breaker foot rot fungus began at the Lind station in the 1961-1962 season. The trials at Lind demonstrated that spring tillage can increase foot rot losses, and at Lind the varieties all lost about the same amount from the disease. After some dry seasons, trials at Lind were abandoned and the program moved to Pullman.

Breeding nurseries at Pullman have been inoculated every year since the 1963-1964 season. Under high production conditions the varieties differed as to losses from foot rot. In 1965, for example, healthy Wanser yielded 94 bushels at Pullman, and diseased Wanser only 20 bushels. An Odin derivative yielded 88 bushels per acre healthy and 71 bushels diseased. This demonstrated the possibility of developing varieties adapted to early seeding on summer fallow could reduce foot rot losses to tolerable levels, even in the more humid parts of the region.

At the present time two possible varieties produced by the USDA, C59287/101-66437 and (14 x 53/Odin) /CI 13431 S. 6425, yield well under foot rot conditions at Pullman. The average yield for four seasons is as follows:

	Healthy	Diseased
(14 x 53/Odin)/CI13431 S. 6425	109	90
Gaines	100	64
C59287/101-66437	86	86
Burt	71	37

Whether either of the above two new varieties is released or not, the potential value of continued breeding and testing is obvious. Soft wheats with foot rot resistance adequate for Washington conditions can be developed. No resistant bread wheats are known and this part of the wheat industry should receive attention.

The release of varieties with adequate resistance to foot rot will improve erosion control in the hilly summer fallow areas by permitting earlier seeding, and it will reduce pollution of our streams and lakes with silt.

The Washington State Wheat Commission has supported this project since its inception, and their faith in this effort may soon begin to pay dividends. When the work began, there was no commercial variety in Washington with any real degree of resistance.

Benlate, a systemic fungicide produced by DuPont, can control straw breaker. Trials on dates and rates of spraying are underway. Whether or not the fungicide will be cheap enough to be economical is not known.

WHEAT, OATS, BARLEY

Dr. Kenneth J. Morrison

Winter Wheat

Nugaines

Nugaines is a semidwarf white winter wheat released for use in Washington and other parts of the Pacific Northwest where Gaines, which it closely resembles, has proved to be well adapted. Outstanding superior characteristics of Nugaines are improved test weight per bushel and milling properties. The variety has a bearded, common-type head with white chaff. The kernels are classed as soft white. The head grows slightly more erect than Gaines.

Nugaines is not as winter-hardy as McCall or Wanser hard red winter wheats, but is slightly hardier than the club wheats. Nugaines is similar to Gaines in hardiness.

Nugaines has good mature plant resistance to stripe rust. It also has more stripe rust resistance than Gaines, but less than Moro. Nugaines, like Gaines, is susceptible to stripe rust in the seedling stage.

Nugaines is similar to Gaines in resistance to all known races of common smut and most races of dwarf smut. Nugaines has moderate resistance to flag smut and stinking smut.

Gaines

Gaines is a semidwarf soft white winter wheat. It has a common-type, bearded head with white chaff. In high rainfall areas, the straw is about 18 inches shorter than other varieties. In low rainfall areas, it is usually about 4 inches shorter. The straw is strong and stiff and resists lodging. Gaines is similar to Burt and Brevor in winter hardiness. It is not as winter hardy as Wanser or McCall. Gaines has fair mature plant resistance to stripe rust, but is susceptible in the seedling stage. It resists all known races of common smut and most races of dwarf smut. Gaines is higher yielding than any of the other currently recommended varieties except Nugaines. It is recommended in Eastern Washington areas with 11 or more inches of rainfall, on irrigated land in Central Washington, and in Western Washington.

Moro

Moro, a white club wheat with red chaff was released by Oregon and Washington experiment stations and the U. S. Department of Agriculture. It was developed at the Pendleton Branch Experiment Station, Pendleton, Oregon.

Its chief advantage over Omar is that it is resistant to stripe rust. Moro is more resistant to dwarf bunt and commont bunt also.

It emerges fast and yields the same as Omar when stripe rust is not a factor. When the disease is sever, Moro produces much better yields than stripe rust susceptible varieties.

Moro is a good pastry flour, however it has a higher flour viscosity than older club varieties that may make it less suitable for some uses.

Moro is a medium tall club variety, about two days earlier maturing than Omar. Its kernels are white and has brown chaff. Moro does not have the high yield potential of Gaines in the higher rainfall areas. The same fertilizer program is recommended for Moro as for Omar.

In the lower rainfall areas of Washington where it is difficult to obtain stands with Nugaines, Moro will germinate and emerge much better than Gaines from deep seedings in dry dusty seedbeds.

Brevor

Brevor is a soft white wheat variety. It has short, stiff straw and resists lodging. Brevor has a common, beardless, white-chaffed head and is moderately resistant to shattering. It has high smut resistance, but is somewhat less resistant than Nugaines or Gaines. Brevor has fair mature plant resistance to stripe rust, but is susceptible in the seedling stage. In areas with less than 14 inches of rainfall, Brevor yields less than Omar. Brevor is recommended in areas with 14 or more inches of rainfall in Eastern Washington.

Burt

Burt is a hard white bread-type wheat. It has a common-type, bearded head with white chaff. Burt is highly resistant to all races of common smut and to most races of dwarf smut. It is slightly less resistant to stripe rust than Brevor and Gaines. It has short, stiff, lodge-resistant straw. Burt is recommended in the drier areas where the rainfall is 14 inches a year or less.

Wanser and McCall

Wanser and McCall are hard red winter wheats developed for low-rainfall areas of Washington. Both varieties yield as well as Gaines in areas that have less than 11 inches of annual rainfall.

The two varieties can be distinguished by chaff color. Wanser has a brown-chaffed head; McCall a white-chaffed head. Both have bearded, common-type heads and medium-height straw that resists lodging.

Wanser is recommended for the southern half of the Big Bend. Its superiority over McCall in stripe rust tolerance and winter hardiness is important for maximum production.

McCall is well adapted to the northern section of the Big Bend area - including Douglas, Grant, and Lincoln counties. McCall is superior to Wanser in both snow mold tolerance and emergence from deep seedings - two qualities important to production in this area.

Wanser is as winter hardy as Itana. McCall has good winter hardiness, though less than Wanser. Both Wanser and McCall are more winter-hardy than Burt, Gaines, or the club wheats.

Wanser and McCall are more shatter resistant than Burt. They will shatter more than Itana, but are easier to combine and thresh clean.

Both varieties compare favorably with Itana in milling and baking characteristics. Wanser mills somewhat better than McCall. McCall has slightly better bread-baking quality than Wanser or Itana. Neither is suitable for production of soft white wheat products.

Wanser and McCall have higher yield potential than Itana, Columbia, or Cheyenne. Their potential is equal to that of Burt in the recommended areas.

Spring Wheat

Marfed

Marfed is an early to mid-season common soft white variety with medium tall, stiff, white straw. It has a beardless, white-chaffed head. Marfed is more resistant to common smut than Federation. It tillers more than Federation, but otherwise is quite similar. When spring seeded, there is no lodging difference between Marfed and Federation. However, when fall seeded, Marfed has lodged somewhat more than Federation. Marfed resists shattering. It has fair seedling resistance to stripe rust and some mature plant tolerance. Marfed is recommended in the areas of Eastern Washington with 10 or more inches of rainfall and for spring seeding in the irrigated areas of Central Washington.

Idaed-59

Idaed-59 is a common soft white wheat that is very similar in appearance and growth habits to Idaed. It matures early and has short, medium stiff straw. Idaed-59 has a beardless, white-chaffed head. It has fair field resistance to stripe rust and is resistant to the stem rust common in Eastern Washington. It resists shattering. In late seedings, Idaed-59 matures from 7 to 10 days earlier than other spring wheat varieties. In the higher rainfall areas, it is well suited to late seedings on heavy soils and early seedings on shallow soils. Like Idaed, some dry area seedings may not be uniform in height at harvest time, making harvest difficult. Idaed-59 is recommended for spring seeding in the 12-inch and higher rainfall areas and for late seedings on irrigated land in Central Washington.

Baart

Baart is a bearded white wheat with a slender open head. The kernels are rather long, large, yellowish, and soft to semi-hard. Baart is an early to mid-season variety. It has tall, weak straw and may lodge on heavier soils. Baart resists shattering, but is susceptible to all common wheat diseases, including smut. Baart is high yielding in the dryland areas of Eastern Washington. It is recommended in the 8-to-12 inch rainfall belt.

Henry

Henry is a hard red spring wheat. It is a mid-season variety with stiffer straw than Baart. It has a bearded head and is moderately resistant to shattering. It yields slightly less than Baart, but more than the other hard red spring wheat varieties commonly used for reseeding in the Eastern Washington dryland areas. Henry is recommended for reseeding in the hard red winter areas of Eastern Washington. Mixtures of Henry and hard red winter wheats may be graded down somewhat less than mixtures of white varieties and hard red winter wheats.

Spring Barley

Gem

Gem is a six-row, semi-rough-awned variety of spring barley. It is high yielding and has stiff straw that resists lodging. It has white kernels, but is not acceptable to the malting industry. Gem is recommended for nearly all areas of Eastern Washington and for irrigated areas in Central Washington. It is not recommended in the Goldendale area or in the glaciated valleys of Pend Oreille, Stevens, Okanogan, Chelan, and Ferry Counties.

Unitan

Unitan is a six-row barley with semi-smooth awns, white chaff, and white kernels. Kernel characteristics and test weight are similar to Gem. Unitan matures three to six days later than Gem. It is easier to thresh than Gem. Unitan is slightly taller than Gem and has about the same straw strength. In the lower rainfall areas, Unitan has yielded more than Gem. Unitan is recommended as a feed barley only in both the high and low rainfall areas of Eastern Washington.

Piroline

Piroline is a two-rowed malting barley that has a higher yield record than Hannchen or Hanna, the standard two-rowed barleys that have been grown for malting purposes.

Piroline is awned, with white kernels, and has a stiff straw that resists lodging. Piroline is about a week later than Gem and is recommended in the higher rainfall area of Eastern Washington.

Traill

Traill is a medium tall, six-row, spring malting barley. It matures a few days later than Gem. It has a rough, long beard and moderately stiff straw. The kernel size is small to medium. Traill may shatter if left standing after it is ripe. Traill is recommened for malting barley production in the high rainfall areas of Southeastern Washington.

Atlas -46

Atlas-46 is a six-row, rough-awned, spring variety with tall straw. It has blue kernels. Atlas-46 has good malting quality and is recommended primarily for the area represented by the Pomeroy trials.

Belford

Belford is a six-row, hooded or awnless variety of spring barley. It is midseason in maturity and medium tall. The straw is relatively weak. Belford is recommended for hay only in Eastern Washington high rainfall areas and in Central Washington under irrigation.

Winter Barley

White Winter

White Winter (Idaho Club) is a six-row winter barley. It is moderately winter hardy and resistant to mildew. White Winter has rough awns and compact head. In fall seedings, it matures early; in spring seedings, it is late maturing. When spring planted, its earlier growth is sprawling and at maturity it is medium tall. Its stiff straw makes it more resistant to lodging than other varieties. White Winter can be used for malting. Spring-sown White Winter has yielded somewhat less than other varieties. When fall sown, White Winter generally outyields spring varieties. White Winter is recommended for fall seeding in areas with 18 or more inches of rainfall in Eastern Washington.

It is not recommended for spring planting.

Luther

Luther is a mutant selection derived from treating seed of Alpine with diethyl sulfate. Luther has a higher yield record than Alpine or White Winter. It is more lodge-resistant than these two varieties because Luther is 5 to 7 inches shorter. Tests indicate that this short-strawed mutant responds to fertilizer in most locations and can be fertilized with a minimum of lodging. Luther is more winter hardy than Alpine and considerably more winter hardy than White Winter.

Luther is a feed barley and is not acceptable to the malting industry.

Alpine

Alpine is a six-row, semi-club barley. The kernels are medium large and the beards are rough. Alpine has tall, stiff straw and is more lodge resistant than White Winter or Olympia. It has less head snapping than Olympia or White Winter. It appears to be slightly more winter hardy than White Winter. It can be seeded in the spring, but yields are lower than for the recommended spring varieties. Alpine has given good yields when fall seeded. It is a feed barley and is not acceptable for malting. Alpine is recommended for the high rainfall areas of Eastern Washington and on irrigated land in Central Washington

Oats

Cayuse

Cayuse is a high-yielding, moderately early spring oat recommended in Washington and Northern Idaho. 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 test weight, which is relatively lower than that of Park. The test weight of Cayuse has averaged about 35 pounds per bushel in all Washington locations - compared with 37 for Park.

Cayuse has some tolerance to the most serious oat disease in Washington - yellow dwarf or "red leaf of oats." The yellow dwarf tolerance of Cayuse can be seen mainly in its high-yielding ability. Discoloration results after severe attack by aphids carrying the virus.

No other disease of consequence has attacked Cayuse in any Washington locations since testing began in 1959.

Although Cayuse is susceptible to node blackening and stem break, these diseases do not affect oat yield in Washington.

Park

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

RECOMMENDED VARIETIES - WHEAT, OATS, BARLEY

AREA	WINTER WHEAT	SPRING WHEAT	OATS	SPRING BARLEY	WINTER BARLEY
EASTERN WASHINGTON 14 inches or more rainfall	Moro Nugaines Brevor Gaines	Federation Marfed Idaed-59	Cayuse Park	Gem Unitan Atlas-46 - malting barley Traill - malting barley Belford - for hay only Piroline - malting barley	White Winter - 18 inches or more rainfall Luther
EASTERN WASHINGTON Less than 14 inches rainfall	Wanser McCall Moro Burt Nugaines Gaines - 11 inches or more rainfall	Baart 8-12 inches rainfall Henry-for reseeding in hard red winter Marfed-10 inches or more rainfall Idaed-59 12 inches or more rainfall		Gem Unitan	
CENTRAL WASHINGTON Under irrigation	Nugaines Gaines	Marfed Federation Idaed-59	Cayuse Park	Gem Belford - for hay only	Luther Alpine

TILLAGE PRACTICES

Tillage Practices For Dry Land Wheat Production

In the dry land wheat production areas of eastern Washington, water is generally the limiting factor for maximum wheat production. Since water is limited, the management of our soils during the fallow period becomes extremely important. Practices which allow maximum intake of precipitation and tend to limit evaporation or loss during the summer fallow year are essential. Date of seeding, proper fertilization, and use of adapted varieties are also important factors in reaching maximum yields with a limited water supply. The subject of this discussion will be primarily concerned with tillage practices related to moisture conservation.

Eastern Washington has a winter rainfall pattern. Approximately 70% of the precipitation occurs from October through April. During this period, temperatures are low and evaporation is at a minimum. Stubble fields should be in a condition to absorb all precipitation that occurs during this period.

Conservation of moisture should start as soon as the crop is harvested. The stubble should be worked immediately in areas where active weed growth occurs. These weeds are removing deep soil moisture that could be used by the next crop. In the low rainfall areas sweeping at a depth of 4 to 5 inches will usually kill these weeds, provided there is enough overlap in the sweeps. This leaves the soil somewhat pulverized, and a fall chiseling after rain will put the soil in a rough condition which will help increase moisture penetration.

In areas where the soils are frozen during some portion of the winter months, the soils should be chiseled. Depth of chiseling in the southern areas, where snow accumulation is low, should be 8 to 10 inches. In the northern areas where more snow is expected to accumulate and the soils freeze deeper, the soils should be chiseled to a depth of 10-15 inches. In areas of high snow accumlation, subsoiling to a depth of 24 inches will increase wat er penetration of the soil. These operations should follow the contour of the land to be most effective. Chiseling also helps prevent the formation of implement hard pans caused by the weight of implements operated at the same depth over a period of years. When implement hard pans have formed, crop root penetration is retarded and the rate of water downward movement is slowed down. Fall chiseling of stubble will probably be of less importance in areas that are relatively frost free, but all of the wheat production area is subject to frozen soils during some parts of the winter. Summer fallow fields that are being left over the winter for a spring crop, should be chiseled after the soils have frozen to a depth of 2 inches to leave the soil in a rough condition.

The initial spring tillage operation should be one to kill volunteer grain and weed growth and work up a mulch for weeding operations. As much stubble as possible should be left on the surface. The amount of straw that the drills can handle at seeding time should be left on the surface. Straw on the surface will reduce evaporation of water from the soil and will give good protection against wind erosion. The depth of spring tillage should be deep enough to insure that an adequate depth of mulch can be established, generally an inch deeper will be sufficient. Deeper tillage depths have no beneficial effects and in some cases, especially on light soils, may have less moisture in the seed zone in the fall.

After the initial spring tillage with a sweep, offset disc, or similar implements, skew treading with the teeth in packing attitude will help firm up the soil, break up heavy straw, and kill small weed growth. Rotary hoes pulled backward or discs pulled with a small cutting angle are also effective in firming up the soil after initial tillage. Usually rod weedings after these operations is all that is necessary for weed control. Fields should not be allowed to "green up" before weeding, because when weeds get that large, they are using moisture rapidly. Research data at Lind indicates that a $4\frac{1}{2}$ inch weeding depth is most effective in conserving soil moisture. In areas of cooler temperatures, a shallower depth may be as effective. In light sandy soils, skew treading may be too severe, and the rod weeder may be the only tool to use after initial tillage. If this is the case, weeding operations should take place as soon as possible after the initial spring tillage, to seal off the moisture below the weeding depth.

Fertilizer applications may have an effect on soil moisture. Unless fertilizer is applied immediately before seeding, the application should be made early in the summer fallow season before soil temperatures are high to prevent moisture loss. Applications should be timed just previous to a normal weeding operation. This will disturb the soil moisture less than if the fertilizer operation is not followed by a weeding.

Research at the Dry Land Research Unit at Lind show that early seeded wheat makes more effective use of moisture than late seeded wheat. The efficient use of moisture by early seeding is probably due, in part, to the increased growth made during cool temperatures. Late seeded wheat develops under higher temperatures especially during the stages of rapid growth of tillering, boot, and heading. In addition to rapid growth, the young cells of growing wheat require more water. Transpiration rates are higher in young cells than in maturing tissues. Early seeded wheat is in a more advanced stage when high temperatures occur. Early seeded wheat also develops a more extensive root system by spring, and is better able to supply nutrients moved down deep in the profile by winter moisture.

The problem of early seeding is to have enough moisture in the seeding zone for seeding in late August or September. Equipment is available which will seed to depths of 6 to 7 inches and still not cover the seed more than 4 to 5 inches. Most of the deep furrow drills are on 14' row spacing. Results from this study at Lind, and another trial at Dusty, show row spacings up to 20 inches will not decrease yields in the range of 30 to 80 bushels per acre. With wider row spacing, furrowing can be deeper, and the total depth of seed coverage can be less. Row spacings of 20 inches would allow seeding to a depth of 8 inches and still not cover more than 5 inches. Wheat will emerge in light soils readily from this depth.

In summary, tillage should be designed to allow free penetration of water during the winter following harvest. During the summer fallow year the tillage and fertilizing operation should hold the moisture close enough to seed early in the fall. A seeding date of approximately September 1, with a range of 15 days either way, would cover the optimum seeding date for most of the dry land area. The following program of stubble mulch tillage is recommended for the 8 to 12 inch area:

1. After harvest, sweeping where weed infestation occurs.

2. Late fall chiseling to a depth of 8 to 12 inches on spacings of not more than 24". The deeper chiseling is recommended for areas of deep frost or heavy snowfall, and wider spacing can be used.

3. Initial spring tillage should be deep enough to ensure an adequate depth of mulch.

4. Follow soon after with skew treader, rotary hoe, light discing (disc almost straight), or rod weeder to firm up soil and establish mulch depth. The deeper mulches are recommended for areas of high summer temperatures.

5. Fertilizer should be applied to late spring or immediately before seeding.

6. Deep furrow seeding of recommended variety starting approximately August 25 in Douglas County, September 5, in areas similar to Lind, and September 15, in 11 to 12 inches rainfall areas of Lincoln County. It is better to have a stand of wheat seeded 10 days too early, than a poor stand of wheat seeded at the optimum time or seeded late.

7. Seeding rate for early seeding should not exceed 45 pounds per acre, and 25 pounds is enough for early seeding that germinates well.

Tillage Practices for Moisture Conservation

Dr. F. E. Koehler and Mike Lindstrom

In 1965 the Washington Wheat Commission began supporting a project to study the "Factors affecting water conservation for plant growth in the low rainfall areas of eastern Washington." The purpose of this project is to determine which soil structural and physical condition as influenced by tillage will provide the maximum moisture for the wheat crop with special emphasis on the moisture in the seed zone. This would increase the probability of getting a good stand of wheat from an early seeding. Previous research has shown that maximum efficiency of use of the limited moisture supply of this area can be obtained from an early seeding.

Fall tillage treatments studies have been: (1) Disc at 5-6 inches deep, (2) Chisel at 9-10 inches deep with chisel points on 12 inch centers, and (3) No fall tillage. Spring tillage treatments studies have been: (1) Disc at 5-6 inches deep, and (2) Sweep at 5 inches deep with 18 inch shovels on 12 inch centers, and (3) Sweep at 8 inches deep. The three spring tillage treatments were applied to each fall treatment giving a total of nine different tillage treatments. All tillage treatments were then gone over with a skew treader to firm up the soil and then rod weeded. Plots have also been set out which received no tillage except for fall tillage treatments. Weeds were controlled in these plots by chemicals.

Fall and Spring Tillage Study

Fall tillage on the 1968-1969 fallow plots markedly influenced soil water storage during the winter season. Mild weather causing snow melt plus rain on frozen soil caused runoff on the non-tilled and fall disced plots. The chisel plots retained the precipitation and possibly received additional water as runoff from the non-tilled and disced plots that were above the chisel plots. The influence that fall tillage treatments had on moisture storage and other factors are shown in Table 11.

Table 11. Influence of fall tillage on moisture storage, percent efficiency during fallow season, loss during summer, and percent water content by weight on September 8, 1969 at the 6 inch depth.

	Water in 6 ft profile		Summer loss		Efficiency	Water content at 6'' depth
	May 7 inches	Sept 8 inches	in	%	%	% by weight
Chisel	13.2	12.1	1.1	8.3	64	10.5
Disc	10.7	10.2	0.5	4.7	48	9.2
None	9.8	9.3	0.5	5.1	40	9.1

The above data show the importance of fall chiseling when runoff occurs. In previous years of this study there was no runoff and no differences due to fall tillage treatments.

The greater loss of water during the summer on chiseled plots was due to movement below 6 feet rather than to evaporation. Evaporative water loss during the summer was essentially the same for all fall treatments. The higher water content in the seed zone in the fall chiseled plots is attributed to the higher stored water in the soil profile.

Spring tillage treatment had no effect on the total water content of the soil profile or in the seed zone. From this year's data and from data collected in past years, it appears that the type of spring tillage has little or no effect on fallow water storage and seed zone water conditions. In all spring tillage treatments, care was taken to insure a good soil mulch on all plots. Observations have indicated that this is probably the most important factor influencing the seed zone water content and the type of equipment used is secondary.

The tillage plots were seeded to Wanser wheat on September 11 and 12. Emergence was influenced by fall tillage, but not by spring tillage. Emergence notes taken on November 1 showed chiseled plots with 42 percent emergence, disced plots with 41 percent, and non-fall tilled plots with 30 percent. Emergence was hindered by 0.3 inches of rain six days after seeding so all plots were rotary hoed to break the crust that had formed.

Five and one-half inches of water was applied to a complete set of the tillage plots in the early spring to saturate the profile to a depth of 6 feet. Here tillage had not effect on profile water loss or on the water content of the seed zone at planting time. A good mulch was established on all plots in the spring which probably was more important than the type of preceding tillage.

Effect of Time of Spring Tillage

Plots were established in the fall of 1968 to study the effect of time of spring tillage on fall chiseled and non-tilled land. Dates of spring tillage were: early - March 20, normal - April 10, late-May 7, and very late - June 6. The early tillage was performed about one week after the frost had disappeared. Normal spring tillage coincided with farmer activity in the Lind area. Weeds were controlled with chemicals and all plots were free of weeds.

The influence of fall tillage on overwinter water storage was the same as that reported for the fall and spring tillage plots. The time of spring tillage had no effect on the total water content in a 5-foot profile measured in late July. A total of 2.7 inches of rain occurred between the early tillage and the very late tillage. This rain was not stored in either the early spring tilled plots or in the later-tilled plots. Water loss in the spring from the fall chiseled plots did no differ from that of the non-fall tilled plots. By spring the fall-chiseled plots were well sealed which may possibly explain why the loss from the two treatments was similar. Water content measurement in soil samples obtained from the surface foot of these plots showed that the earlier spring tilled plots had slightly higher water content than did the later tilled plots. Emergence was also improved in the earlier spring tilled plots (Table 12). The plots were seeded on September 12 and emergence notes were taken on November 1. These plots were also rotary hoed to break up the surface crust from the mid-September rain.

Table 12. Effect of time of spring tillage on water content at 6 inch depth and percentage emergence.

	Spring Tillage							
	Early		Normal		Late		Very Late	
	% Water	% Emerg	% Water	% Emerg	% Water	% Emerg	% Water	% Emerg
Chisel-Fall	9.8	70	9.7	73	9.1	53	9.4	52
Non-tilled	9.5	46	8.9	35	8.8	38	8.9	33

Tilled vs. Non-Tilled Plots

This study is being conducted to measure the effect tillage has on water retention during the summer on total storage and seed zone moisture content. No fall tillage was performed on either treatment. The tilled plots were swept in the spring, skew treaded, and then weeded as necessary. The non-tilled plots were never worked and weeds were controlled by chemicals. Depth of mulch on the tilled plots was about 2 inches. No differences in total water content in a 6 foot profile were measured between the two treatments. In late July, the water content in the surface foot was higher in the tilled plots than in the non-tilled plots. By September, this difference had disappeared and the water content for the two treatments was similar. From late July to September, the tilled had a greater reduction in water content from the surface foot than did the non-tilled plots. The reason for this is not completely understood, but it is thought that during August the replenishment of water in the top foot from lower depths was not able to keep pace with the evaporation rate. Evaporation from the non-tilled plots was slower than from the tilled plots because of lower water content, so subsequently the water contents in the top foot became the same. Evidence for this is from another set of plots with identical treatments, except to which $5\frac{1}{2}$ inches of water was added in the early spring. The water content in these plots was higher in the surface than in the natural water plots and the remainder of the profile was saturated. These plots showed less water loss from the surface foot of soil than did the natural water plots. Loss of water was occurring, but replenishment from lower depths was keeping pace with evaporation because of a higher subsoil water content. The moisture content of the two treatments was the same in late July. The soil water content of the surface foot of the non-tilled plots was slightly lower than that for the tilled plots. The tilled plots showed no reduction in water content in the surface foot from late July to September, while the non-tilled plots showed a loss in water content.

Emergence from the natural water plots was 80 percent in the tilled plots and 50 percent in the non-tilled plots. From the plots which received the additional $5\frac{1}{2}$ inches of water the emergence was 90 percent for both treatments. The wheat on these plots had emerged before the mid-September rain. Difference in emergence between the tilled and non-tilled in the natural water plots was attributed to the seed zone drying out after planting in the non-tilled plots. After seeding the shank tracks in the non-tilled plots remained cloddy and open whereas the tracks in the tilled plots were filled in and packed with finer soil from the mulch.

Fallow Tillage Depth and Soil Water in the Seed Zone
R. I. Papendick

Maintaining adequate soil water in the seed zone is a major problem with early fall seeding in the wheat-fallow areas. Management practices during the fallow period can markedly influence the retention of water in the seed zone. One important factor is the depth of soil mulch produced by fallow tillage. Studies at Lind showed that the loose, dry soil, or "dust" mulch insulates the underlying moist soil, decreasing its temperature and reducing evaporative loss, particularly during hot weather. Water loss from soil particularly near the surface, increases markedly with increase in soil temperature. In one experiment, soil temperatures in the seed zone during August and early September averaged several degrees lower with a $4\frac{1}{2}$-inch dust mulch as compared to a $2\frac{1}{2}$-inch mulch. The lower temperature resulted in a higher seed zone water content, and as a result, wheat emergence was more rapid and final stands were complete earlier with the deep soil mulch. A 2-ton per acre straw mulch in addition to the soil mulch improved the seed zone water condition slightly with the shallow dust mulch, but had no effect with the deep mulch. Apparently, the insulating effect of the straw was masked completely by the deep soil mulch.

The loose dry surface layer conserves water also by acting as a barrier to liquid water flow from the moist soil to the surface. Packing the surface layer or leaving it in a firm condition enhances water conduction upward, and during hot weather increases heat conduction downward. Studies at Lind and outlying locations showed that seed zone water contents at seeding time were higher where rodweeding was used to establish a dust mulch as compared to no rodweeding and chemicals to control weeds. However, leaving the surface layer cloddy and open, a typical condition following spring sweep tillage, can result in large water losses from the tillage layer. This is because water vapor flow through a cloddy open layer is greatly enhanced due to the increased proportion to large pores, many of which are exposed at the soil surface.

Both the insulative and barrier effects of the soil mulch depend on secondary tillage depth. Thus, in warmer areas a greater mulch depth may be needed to effectively conserve seed zone water than in cooler areas. Optimum tillage depth will also be influenced by soil type, amount of straw mulch, and the physical condition (aggregation, density) of the soil mulch. Assuming a fine soil mulch, tillage depth becomes less important with heavier, and more moist soils, and coller weather.

MANAGEMENT PRACTICES FOR WHEAT PRODUCTION UNDER SUPPLEMENTAL IRRIGATION

Dr. Fred E. Koehler, Michael J. Lindstrom, Charles Boyd

This project, designed to find the best soil fertility and other cultural practices necessary for wheat production to utilize limited irrigation water most effectively, is being supported by the wheat industry through the Hay and Grain fund. Data has been obtained from experiments in 1968 and 1969 at the Lind station.

Irrigation treatments for the 1968 and 1969 experiments were (1) irrigation in early April, (2) one irrigation in early May, (3) two irrigations (as in 1 and 2 above) and (4) three irrigations, as in 3 above plus one in early June. Each irrigation treatment received six nitrogen treatments, 0, 60, 120, 180, 240, and 300 lbs. N per acre.

The yields and protein concentration of grain are given in Table 13.

Table 13. Yield and protein concentration of Gaines wheat grown with different levels of N fertilization and supplemental water application. Lind, 1968 and 1969.

Rate of N lb/a	April		May		April &May		April-May-June	
	1968	1969	1968	1969	1968	1969	1968	1969
				Bu/a				
0	35	26	33	34	31	26	35	31
60	46	31	46	41	58	53	59	53
120	51	32	48	44	68	59	71	63
180	48	39	43	43	65	60	68	64
240	49	45	45	36	64	53	72	66
300	44	45	46	42	63	60	76	71
				% Protein				
0	6.4	12.2	6.9	11.8	6.6	11.3	6.9	10.8
60	8.8	12.2	8.0	12.2	7.3	12.2	7.8	11.5
120	10.8	12.3	11.4	13.2	8.3	12.2	9.3	12.2
180	12.3	12.8	12.4	12.9	10.8	12.7	10.6	12.6
240	12.5	12.4	13.6	13.3	11.8	12.4	11.6	12.3
300	13.4	12.0	13.0	12.8	12.9	12.7	12.1	12.3

Sixty pounds of N per acre gave near maximum yields where only one irrigation was used. With two or three irrigations, maximum yields occurred at about 120 lbs N per acre. Yields were reduced both years due to unfavorable weather conditions. In 1968 the crop was damaged by a severe frost which occurred in late April. In 1969 stands were reduced and the remaining plants were hurt because of extreme cold temperatures in late December. For the 1968 crop protein content increased with increasing rates of nitrogen application, but did not reach objectionable levels until after maximum yield had been obtained. The moisture applied, that used by the wheat, and the efficiency of use for 120 lb rate of nitrogen application are given in Table 14.

Table 14. Water application and use by Gaines wheat Lind, 1968

Irrigation No. time	Water applied inches	Water used inches	Yield bu/a	Efficiency of use bu/in.	bu/(in. -4)
1 Apr.	7.4	12.3	51	4.1	6.1
1 May	6.1	11.5	48	4.2	6.4
2 Apr-May	13.5	16.4	68	4.1	5.5
3 Apr-May June	16.4	22.6	71	3.1	3.8

The wheat used water with approximately the same efficiency when one or two irrigations were applied. However, the June irrigation increased yields only slightly so this last application of water was essentially wasted as far as grain production was concerned.

Similar data has been collected for the 1969 crop, but is not reported because the results were more influenced by the winter damage than by management treatments.

Additional studies being conducted this year include time of nitrogen application-Fall vs spring and split application; time of a once over irrigation; Fall vs spring, phosphorus and sulfur application with irrigation; and trace elements.

TREES AND SHRUBS FOR DRY-LAND PLANTING

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

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

The past several years have been extremely hard on many trees and shrubs. The weather has been very dry, and the hard winter of a year ago is still showing its effect on many of the plants.

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

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

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

Table 15. Standard species, arrangement, and spacing of trees and shrubs for windbreak plantings in the 8-10" rainfall area.

Row No.	Species	Growth Habit	Spacing in Row	Minimum distance from next Row*
1	Caragana	Erect shrub	3 ft.	18 ft.
2	Russian olive	Intermediate shrub	6 ft.	18 ft.
3 & 4	Black Lucust	Deciduous tree	12 ft.	18 ft.
5	Austrian pine Scotch pine Ponderosa pine Rocky Mt. Juniper	Evergreen	12 ft.	27 ft.

*Rows can be spaced wider apart if cultivation equipment requires it.