FIELD DAY

Dry Land Research Unit

Lind, Washington

June 29, 1971

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 55th 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	Temperature °F.		Precipitation		Precipitation 50 yr. av. (in.)
	Max.	Min.	1970	1971	
January	34	22	2.89	.89	1.05
February	42	24	1.27	.33	.91
March	53	32	.74	1.44	.71
April	63	35	1.07	.71	.64
May	72	42	.46	1.06	.76
June	83	45	.35		.93
July	90	52	.12		.21
August	90	50	.06		.31
September	79	45	.24		.55
October	65	38	.80		.91
November	47	29	1.27		1.21
December	37	26	.62		1.26
			9.54		9.44

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 OF CEREAL CROPS

The objective of 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 is 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 the 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 1965-70.

Variety	1965 17 locations	1966 22 locations	1967 21 locations	1968 15 locations	1969 17 locations	1970 15 locations	6 yr. av.	% Kharkof
Wanser	60.5	46.3	48.6	53.1	44.7	50.6	50.6	118
McCall	63.5	45.1	47.5	48.9	46.9	49.1	50.3	117
Cheyenne	56.7	42.3	43.4	46.0	45.2	46.8	46.8	109
Itana	52.7	40.6	39.0	46.0	44.0	45.1	44.6	104
Kharkof	52.7	37.5	40.8	42.5	42.5	41.7	43.0	100

Table 3. Yield of selected varieties in low and intermediate rainfall areas in Washington and Oregon, 1964-70.

Variety	Location and Rainfall				
	Lind 9.5"	Moro, Ore.* 11"	Pomeroy 14"	Pendelton 14"	Average
Nugaines	41.1	33.0	65.4	69.5	53.0
Luke**	40.1	52.4	57.7	71.8	52.2
Burt	36.7	32.4	53.3	59.7	46.0
Coulee**	34.5	33.1	55.7	66.6	47.4
Moro	39.5	33.2	56.6	58.7	47.5
Omar	36.3	31.0	53.6	54.5	44.3
Paha**	38.3	31.1	62.2	70.8	50.7
Wanser	38.9	35.3	54.8	61.4	48.1
McCall	39.1	33.4	54.7	61.4	47.7
Cheyenne	37.9	32.7	53.9	54.9	45.3
Kharkof	34.9	27.9	49.4	49.7	40.9
Station Average	38.0	32.7	55.7	59.9	47.0

*Moro location 6 years - 1965 missing
**3 yr data, except Luke, 1 yr at Moro and Pendleton

McCall and Wanser are adapted to areas now growing hard red winter 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 content for blending with higher protein wheat.

In Tables 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. Variety recommendations for the different rainfall areas are included in this brochure in the section by Dr. Morrison.

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. Higher yield is urgently needed for spring wheat varieties.

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

	HARRINGTON 1952-70			HORSE HEAVEN 1951-70		
Variety	No. years grown	% Kharkof	Av. yield bu/a	No. years grown	% Kharkof	Av. yield bu/a
Gaines	9	145	46.9	6	120	18.7
Nugaines	5	155	42.4	---	---	---
Burt	17	125	44.2	10	116	21.1
Moro	5	142	38.7	3	116	15.1
Omar	12	121	41.3	9	115	20.5
Wanser	3	149	38.0	4	119	18.1
McCall	3	154	39.3	4	116	17.6
Cheyenne	---	---	---	9	113	19.7
Kharkof	17	100	35.4	11	100	18.0
Luke	2	184	38.4	1	115	17.6
Paha	3	197	44.5	1	114	17.5
Coulee	3	142	35.9	1	109	16.7

Table 5. Summary of agronomic characteristics of winter wheat grown at Lind in rod row nurseries, 1952-70.

Variety	Av. plant ht	Av. test wt.	1970 yield bu/a	Av. yield bu/a	Yield % Kharkof	No. years grown
Paha	27	60.0	53.1	43.9	132	4
Gaines	26	60.7	---	42.6	127	10
Nugaines	25	62.1	52.2	41.4	121	6
Luke	24	60.2	44.3	38.7	120	3
Burt	30	61.1	44.4	36.3	116	16
Coulee	24	61.7	50.8	36.9	114	3
Cheyenne	32	61.6	49.0	37.4	113	13
Wanser	30	62.3	48.4	38.9	112	7
McCall	30	62.5	46.6	39.0	112	7
Moro	29	58.8	35.9	38.9	112	7
Omar	30	59.3	39.1	35.2	106	13
Kharkof	32	60.6	42.6	31.3	100	16

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	Av. 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
Luke	23	62.7	38.8	38.8	174	1
Burt	31	61.6	25.9	40.2	118	13
Coulee	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
Paha	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 variations grown at the Dry Land Research Unit in drill stripe plots, 1954-70.

Variety	Date head	Plant ht.	Winter* hardi-ness	Stripe* rust	Av yield bu/a	Yield % Kharkof	Test wt.	No. years grown
Paha	6/6	28	6	1	54.4	140	58.6	1
Moro	5/31	30	6	1	40.6	128	58.0	5
Nugaines	5/31	25	5	3	38.8	122	61.1	5
Luke	6/7	25	5	1	47.7	122	57.3	1
Gaines	6/1	24	5	4	40.8	121	60.8	10
McCall	5/30	29	3	5	37.9	119	61.9	6
Wanser	5/28	30	2	3	37.9	116	61.8	7
Omar	6/3	30	6	8	36.8	115	59.2	13
Burt	5/30	30	4	6	36.0	114	60.8	15
Coulee	6/5	25	4	1	44.5	114	59.2	1
Cheyenne	5/29	32	1	4	35.4	111	61.5	13
Itana	5/30	33	2	8	33.6	106	61.7	14
Kharkof	5/31	33	1	4	31.4	100	60.5	15

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

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 winter 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.

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

Marfed is the highest yielding variety at all locations.

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.

Table 8. Summary of agronomic characteristics of spring wheat grown at Lind in rod row nurseries, 1950-70.

Variety	Date head	Plant ht.	1970 yield bu/a	Av. yield bu/a	% Baart	Test wt.	No. years grown
Marfed	6/14	25	22.5	23.8	113	58.8	20
Idaed (Idaed 59)	6/9	25	18.9	20.8	99	59.1	20
Lemhi	6/13	26	23.0	22.2	105	57.8	20
Federation	6/12	25	23.6	22.1	105	58.4	20
Henry	6/11	27	*	20.0	94	59.1	16
Adams	6/13	26	*	23.0	108	59.3	7
Burk/KF 58-2025	6/14	24	19.6	23.8	107	58.0	7
Baart	6/11	28	19.6	21.1	100	60.2	20
Twin	6/12	22	25.6	22.4	116	58.3	3
Peak	6/10	22	17.5	17.5	83	58.9	1

*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 No. years grown	Harrington % Baart	Harrington Av. yield bu/a	Waterville No. years grown	Waterville % Baart	Waterville Av. yield bu/a	Horse Heaven No. years grown	Horse Heaven % Baart	Horse Heaven Av. yield bu/a
Marfed	20	117	30.6	19	114	30.2	17	109	18.5
Idaed (Idaed 59)	20	114	29.6	19	102	26.8	17	100	16.9
Lemhi	20	102	26.5	19	107	28.3	17	101	17.2
Twin	2	112	27.0	2	131	33.9	2	75	5.6
Federation	20	104	27.1	18	106	27.9	17	101	17.1
Henry	17	106	28.2	16	96	25.9	15	96	17.5
Peak	1	91	19.6	1	102	29.1	1	73	4.7
Adams	6	107	27.6	6	107	26.9	6	99	13.4
Burt/KF 58-2025	7	105	25.8	6	102	26.4	6	92	11.1
Baart	20	100	26.0	18	100	26.4	17	100	17.0

Henry/Burt Sel. 65-2 is 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 at Lind for 8 years.

Variety	Av. yield bu/a	% Marfed
Marfed	23.4	100
Idaed	19.5	83
Henry/Burt S 65-2	22.5	96

Two new spring varieties were released in Idaho this year. One is a soft white variety named Twin, which is also recommended for Washington. The second variety is named Peak, and is a hard red spring. It is not recommended for Washington, since the limited data do not indicate it is adapted to Eastern Washington. The yield of these two varieties at four locations are given in Tables 8 and 9.

Progress in developing a white spring wheat has been slow. Although many selections have yields similar or slightly better than Marfed, none have shown outstanding yield. Many are resistant to stripe rust and have good milling and baking quality. With the additional testing at Pullman and Royal Slope sites, one of these selections may prove to be superior enough to warrant release.

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
J. Walter Hendrix, Pathologist W. S. U.

Stripe rust has been described as "capricious" - that is, it's behavior is erratic and it is subject to change without apparent reason. The inconsistent behavior has been evident during the past decade. Varying from a highly destructive disease in the early- and mid-1960's, it has now reached a low point. In fact, very little infection is known to exist in the state this year.

The gradual decline in both the incidence and damage by stripe rust in the last 3 or 4 years is almost certainly associated with the widespread use of resistant varieties. There is good liklihood, however, that other factors have also had an influence. Among the latter are generalized weather patterns, local weather conditions, and planting practices.

Even though there seems to be a high degree of freedom from stripe rust at the moment, let's not be lulled into a state of complacency. The disease has tremendously explosive capabilities and will surely come back sooner or later. Let's hope later.

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, Luke and Paha are highly resistant even as seedlings, to many of the prevailing races of the stripe rust fungus. They are 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 rust 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, W. L. Nelson, 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
Coulee	1	Paha	5
Nugaines	2	Omar	11
Itana	3	Moro	34
(14 x 53/Odin)/CI 13431 S. 6425	3	Luke	40

Moro, developed by Dr. C. Rohde at Pendleton, Oregon, and Luke, developed by Dr. C. Peterson at Pullman, both derive their resistance from PI 178383. On the basis of the 1970 results, Luke 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. However, under extremely severe snow mold conditions in 1971, none of the commercial varieties survived.

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. The use of coal dust and blackening agents to hasten snow melting has also been investigated. Cost of application and danger of late snow fall after treatment makes the value of this treatment questionable.

The breeding program for resistance to snow mold is progressing rapidly. Several very resistant lines are under increase this year. Comparative yield data will be obtained this year and the best lines will be selected for further increase for possible release in two years. The best hard red selections are CI9342/101 Sel 9 - 1 and CI9342/Gaines Selection 38 A. Both of these selections survived heavy snow mold infection the past 3 years. Selection 9-1 survived this year under conditions that completely killed Luke, the most resistant commercial variety. Two white wheat selections with good quality, PI167822/101 Sel. 127-10, and PI181268/Gaines Sel. 399-6 had 100% survival when Luke was completely killed. Both of these have good potential as varieties and are under initial seed increase.

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 that 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, Luke 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)/CI 13431 S. 6425	109	90
Gaines	100	64
Luke	86	86
Burt	71	37

Luke was released in 1970. The potential of this variety to produce under foot rot conditions will be evaluated under production. 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.

Root and Foot Rots of Wheat
R. James Cook

<u>Fusarium</u> root and foot rot (dryland foot rot) caused a considerable yield loss in the 1970 Washington wheat crop--probably more than any other soil-borne disease of wheat in the state. Conditions of inadequate soil moisture and very hot weather during the first week of June, 1970, are credited with favoring the epidemic. In contrast, so far this year, all indications are that the disease will be of minor importance.

The latest research (conducted in cooperation with Dr. R. I. Papendick, ARS, USDA, Pullman) indicates that the <u>Fusarium</u> which causes the foot rot is highly favored, even stimulated, by soil and plant water stresses. We think this may explain why the disease is characteristically most severe in early seeding, with high nitrogen fertility, and along the edges of the field where there is overlap in nitrogen fertilizer application. Each of these practices enhance plant growth, which increases the rate of soil water use. This, in turn, hastens the onset of plant water stress, and favors the foot rot. In essence then, the fungus can cause severe damage only on weakened plants, but plants that would yield much more if not prematurely killed by the disease.

Luke, Paha and Omar have the best resistance to dryland foot rot of all common white and club wheats available. Except for Luke, most common soft white and hard wheats including Wanser, McCall and Coulee, are highly susceptible like Nugaines. The clubs are more resistant, like Omar, although Moro is quite susceptible. Indications are the Omar types utilize the soil water more conservatively, stress more slowly, and thus develop severe foot rot more slowly.

Take-all continues to appear in severe amounts in wheat grown under irrigation on recently reclaimed land of the Columbia Basin. Wheat in the same field for two consecutive years will almost certainly show the disease and yield poorly. Wheat after alfalfa has also been known to develop severe take-all. In contrast, wheat has not shown the severe take-all when grown year after year in the same field and under irrigation, if the field has previous history of dryland wheat and fallow. Indications are that certain organisms present in these soils protect the wheat from the take-all fungus, conferring a form of immunity to the soil. These organisms, still unidentified, apparently are absent or not sufficiently numerous in soils of the virgin sagebrush lands, hence take-all develops there. Wheat on older irrigated lands of the Columbia Basin do not show severe take-all. Perhaps the antagonistic organisms build up in the irrigated Columbia Basin soils after several years of wheat or other crops.

WHEAT, OATS, BARLEY

Dr. Kenneth J. Morrison
Extension Agronomist

Winter Wheat

Suwon 92/4*Burt-6528

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 foot rot 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 selection will be named Coulee if it is released.

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 less resistant to stripe rust than Nugaines. It has short, stiff, lodge-resistant straw. Burt is recommended in the drier areas where the rainfall is 14 inches a year or less.

Paha

Paha 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, 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 foot rot. The variety 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 Paha 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. Seed for commercial wheat production will be available for seeding in 1971.

Moro

Moro, a white club wheat with brown 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 common bunt also.

It emerges fast and yields the same as Omar when stripe rust is not a factor. When the disease is severe, 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 Nugaines 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 Nugaines from deep seedings in dry dusty seedbeds.

Luke

Luke is a soft white semi-dwarf wheat selection for use in counter-acting the recent widespread appearance of new races of dwarf bunt. Parents of this variety 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. Luke is resistant to all known races of common and dwarf bunt is well adapted to areas where new races of dwarf bunt are found on Gaines and Nugaines. This variety is notably superior to these two varieties in resistance to Cercosporella foot rot, snow mold, caused by Fusarium nivale and to stripe rust.

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

Nugaines

Nugaines is a semi-dwarf 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.

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. Both varieties are resistant to common smut and most races of dwarf bunt. Wanser is highly resistant to flag smut.

Wanser is recommended for the southern half of the Big Bend. Its superiority over McCall in stripe rust tolerance and 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 seedlings--two qualities important to production in this area. McCall recovers rapidly in the spring which is another advantage for the northern 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 resistance 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.

Twin

Twin is a soft white spring wheat named and released by Washington, Idaho and Oregon agriculture experiment stations and crop research division, U.S. Department of Agriculture. Twin has a higher yield record under dryland conditions than Marfed. Twin did better under irrigation at

Ellensburg but did not do as well as Marfed at Othello. Twin has a lower test weight than Marfed, it has shorter straw and is more lodge resistant. The variety is resistant to prevalent races of stripe rust but is susceptible to leaf rust and mildew. Twin is an awnless wheat of medium maturity, has white chaff and moderately stiff straw. The variety was developed at the Idaho Branch Experiment Station at Aberdeen, Idaho.

Durum--Wandell

Wandell is a durum wheat released for use under irrigation in the Columbia Basin and irrigated areas. Wandell is a semi-dwarf, spring, late-maturing, amber durum variety. It is resistant to mildew, stripe rust, and is very lodge resistant. It has light tan chaff and awns.

The original cross was made at the North Dakota Agriculture Experiment Station and additional selections made from that cross by Dr. Konzak at Washington State University.

Wandell or other duram wheat varieties should not be growing where mixtures with other varieties may occur.

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 areas 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 recommended 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.

Vanguard

Vanguard is a two-row barley recommended to replace Piroline. The variety has a 250 lb. per acre higher yield than Piroline. It has better lodging resistance. Vanguard matures about the same as Piroline and is the same height. It is a two-row, spring barley with rough awns. The seed size is slightly smaller than Piroline. The variety was developed at Washington State University by Dr. Robert Nilan and Mr. Carl Muir. The variety is a selection from a cross of (Betzes x Haisa) x Piroline. Seed will be available for spring planting in 1972.

Belford

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

Winter Barley

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 generally out-yields 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.

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 lbs. 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, short, white kernels. It can be distinguished from most other oat varieties by its upright leaves, which are dark green in color. Park is a mid-season oat and is medium high. It rarely grows over 42 inches in height under irrigation. The heads are medium short and erect. Park has yielded about the same as Cody or Shasta. Park is recommended to replace Cody because it has more uniform straw height and kernel size. Park can be grown in Eastern Washington in areas with 14 or more inches of rainfall, 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	Nugaines Luke Paha	Marfed Idaed-59	Cayuse Park	Gem Unitan Atlas-46--malting barley Traill--malting barley Belford--for hay only Piroline--malting barley Vanguard	White Winter--18 inches or more rainfall Luther
EASTERN WASHINGTON					
Less than 14 inches rainfall	Wanser McCall Moro Burt Paha Nugaines	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		Unitan	
CENTRAL WASHINGTON					
Under irrigation	Nugaines	Marfed Idaed-59 Wandell (Durum)	Cayuse Park	Gem Belford--for hay only	Luther

WEED CONTROL IN WINTER WHEAT

Dean G. Swan
Extension Weed Scientist
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 dry land wheat area, there are fewer species of weeds to be controlled. Moreover, the weed population is less. In the 10-12 inch rainfall area, 2,4-D is still generally the best choice of herbicide to use. However, the weed problem should be analyzed for weed species, population, soil type, size of weed, etc. before a herbicide program is chosen. One of the newer materials might be the best choice.

In the fall of 1970 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 areas in Eastern Washington.

Downy brome (cheatgrass) continues to be a major problem in the winter wheat-growing areas. 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.

Some of the screening compounds that looked good in 1970 have not looked good in 1971. Either poor downy brome control or crop injury is evident.

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 to 15 inches. In areas of high snow accumulation, subsoiling to a depth of 24 inches will increase water 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 seeding 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 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 inches. The deeper chiseling, or subsoiling 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 in late spring, immediately before seeding, or with seeding.

6. Deep furrow seeding of recommended variety starting approximately August 20 in Douglas County, September 1, in areas similar to Lind, and September 10, 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 30 pounds is enough for early seeding that germinates well.

Tillage Practices for Moisture Conservation and Early Stand Establishment

Dr. F. E. Koehler and Mike Lindstrom

Information reported in this section of the field day brochure has been made possible by Washington Wheat Commission's support of project 1857 entitled "Factors affecting water conservation for plant growth in the low rainfall area 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 to determine the affects of tillage on moisture conservation. Weeds were controlled in these plots by chemicals. Additional studies had been included to study the affects of time of initial spring tillage and surface on total soil profile water content and seed zone water.

Fall and Spring Tillage Study

Soil water accumulation during the winter months has not been affected by fall tillage treatments unless runoff from stubble fields occurred. When runoff occurred, chiseling was the most effective, while the non-tilled treatment was least effective. Data from the winter of 1968-69, in which severe runoff took place, shows an increase of over 3 inches of water in a 6-foot profile in chiseled plots over non-tilled plots.

The types of spring tillage have had no effect on the total water content of the soil profile or the moisture content of the seed zone. In all spring tillage treatments, care was taken to produce a good soil mulch on all plots. The surface mulch produced is apparently the most important factor influencing the seed zone water content and the type of equipment used is not of major importance provided a good mulch is produced.

Data collected since the start of this project show that very little water is lost from the soil profile between initial spring tillage and seeding in the fall. In the natural water plots, the water loss has always been less than 10 percent of the total and generally less than 5 percent of the total water content. In plots that received additional water by irrigation, the water loss during the summer fallow season has been as high as 13 percent, but some of this loss may have been due to movement below six feet or the zone of measurement. Most of the water loss during the fallow season occurs during the winter months from evaporation from a soil surface in which soil pores are continuous and the surface is wet a large portion of the time.

Additional rainfall after the initial spring tillage has contributed very slightly if at all to the total soil moisture content. After the mulch has been established it takes approximately one inch of moisture to saturate the mulch and allow downward movement of water. Less rainfall than this will generally be lost by evaporation. Other studies with time of spring tillage have shown rainfall on delayed spring tillage treatments to be equally ineffective.

This portion of the project has been terminated and future work will be directed towards other factors concerning wheat emergence in the fall.

Time of Spring Tillage Study

Time of spring tillage plots were established to study the effect of the date of initial spring tillage on fall chiseled and fall non-tilled plots. Dates of spring tillage were: early--February 25, normal--March 27, late--May 1, and very late--June 1. The early tillage was performed as soon as equipment could be used in the field. The soil surface was wet at this time. Normal spring tillage coincided with farmer activity in the Lind area. Weeds were controlled with chemicals and all plots were kept free of weeds, regardless of time of initial tillage.

Fall tillage did not influence moisture storage during the winter months (1969-1970). The earlier spring tillage treatments had a slightly higher total water content than the late spring tillage treatment (Table 11). A total of 2.2 inches of rain occurred between the earliest and latest tilling dates. The year before 2.7 inches of rain occurred during this period. These observations indicate that rainfall during the spring season is generally ineffective in contributing total soil water storage. There was no difference between the fall chiseled and the non-fall tilled plots in water loss during the spring period. Water content measurement in soil samples obtained from the seed zone at seeding time showed that the earlier spring tilled plots had a higher water content than did the later tilled plots. The rate of emergence was also faster in the earlier spring tilled plots (Table 11). The plots were seeded August 25 with Nugaines. A 0.2 inch rain crusted these plots 8 days after seeding and percent emergence shown in Table 11 is the amount of wheat that had emerged at the time of the rain.

Table 11. Effect of time of spring tillage on water content (total and seed zone) and percent emergence.

Time of Spring Tillage	% Emergence	% H_2O (4-6 inches)	Total water (inches)
Early	75	9.7	9.3
Normal	76	9.2	9.1
Late	58	8.9	8.8
Very late	37	8.3	8.9

Tilled vs. Non-Tilled Plots

This study is being conducted to measure the effect tillage has on water retention during the summer and on seed zone moisture content. No fall tillage was performed on either treatment. The tilled plots were disced in the spring and then weeded as necessary. The non-tilled plots were never worked and weeds were controlled by chemicals. No differences in total water content in a 6-foot profile were measured between the two treatments. Water content of the surface foot was higher in the tilled plots than in the non-tilled plots as shown in Table 12. This relationship held true in both the natural water plots and in the plots that received $5\frac{1}{2}$ inches of additional water from the irrigation system. Emergence of wheat in the tilled plots was much better than that in the non-tilled plots with natural water. In the plots that received additional water the rate of emergence was the same, but the plants in the tilled plots appeared more vigorous.

Table 12. Comparison of water content and emergence in tilled and non-tilled plots.

Treatment	% H_2O (4-6 inches)		% Emergence	
	Natural Water	Natural water + $5\frac{1}{2}$'' added	Natural Water	Natural water + $5\frac{1}{2}$'' added
Tilled	8.4	12.3	60	80
Non-tilled	7.5	10.1	20	80

Surface Texture

Plots were established in the spring of 1969 and also in 1970 to study the effect of surface texture on moisture retention in the seed zone. Treatments consisted of fine and coarse surface. The initial treatment was performed with a sweep for both treatments. The fine surface was established by skew treading to break up the surface clods and then rod weeded. The coarse surface was only rod weeded. The plots were then weeded as necessary to maintain weed control. Results from the 1969 fallow season were variable. Results from the 1970 fallow season showed no difference in moisture retention in the seed zone and no difference in emergence of fall seeded wheat.

Preliminary studies were started on the use of other equipment in place of the rod weeder for mulch maintenance. A John Deere C150 cultivator was equipped with 9 inch shovels on 6 inch spacing and appeared to be very effective in both weed control and moisture retentions.

Important Results of This Research

Previous work completed within this project has shown the importance of mulch establishment for maintenance of seed zone moisture. The type of tillage equipment used has been shown to be relatively immaterial with regard to moisture retention provided a good mulch has been established. Deep tillage in the spring has tended to be slightly detrimental in years of low moisture. This practice is not too practical because of higher power requirements and generall not as effective in weed control.

It has also been demonstrated that moisture retention during the summer period is very effective for all types of treatments. This holds true even for totally non-tilled plots. The significance of this is that total moisture conservation of the soil profile in summer months is not greatly affected by tillage, but seed zone moisture is strongly dependent on the mulch. It has also been demonstrated that in years when runoff occurs on frozen soils, fall tillage is beneficial and that chiseling is the most effective in increasing water infiltration.

It has been found that water loss does not occur during the summer months as was believed at the start of this project but that the major part of the loss comes during the winter months and early spring season before spring tillage is started. Loss during the winter occurs from small rains that only wet the soil surface and evaporate before downward movement can take place. Loss can also occur during the early spring season by evaporation from a wet surface which is maintained in many cases by freezing and thawing. Early spring tillage has shown only a slight increase in total water content in the soil profile but has produced a higher seed zone moisture content. This would help insure an adequate seeding condition in the fall.

Work on a surface condition is disproving earlier ideas in which it was thought that a fine mulch was necessary for maximum moisture retention in the seed zone. If future work gives the same results as present data, a tillage operation may be eliminated in some cases and a condition less conducive to wind erosion will result.

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 mulch soil. 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 downard. Studies at Lind and outlying locations showed that seed zone water contents at seeding time were higher where rod weeding was used to establish a dust mulch as compared to no rod weeding 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 cooler weather.

MANAGEMENT PRACTICES FOR WHEAT PRODUCTION UNDER SUPPLEMENTAL IRRIGATION

Dr. Fred E. Koehler, Charles Boyd, Marvin Fischer

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, 1969 and 1970, at the Lind Station.

Irrigation treatments were:

1. one 4 inch irrigation in early April

2. one 4 inch irrigation in early May

3. two 4 inch irrigations as in 1 and 2 above

4. same as 3 plus 4 inch irrigation in early June.

Superimposed on each water treatment are six nitrogen treatments, 0, 60, 120, 180, 240, 300 lbs. N per acre.

The yields, protein concentrations, and 1970 test weights are given in Table 13.

In 1968 and 1969, 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. In 1968 and 1969, yields were severely reduced by unfavorable weather conditions. In 1968, the crop was damaged by a severe frost which occurred in late April. In 1969, stands were reduced by winter kill and the remaining plants were injured by the extremely low late December temperatures. For the 1968 crop, protein content increased with increasing rates of nitrogen application, but did not reach objectionable levels until maximum yields were obtained.

In 1970, yields were substantially higher. Due to extremely high NO_3-N levels prior to seeding, 60 lbs. N per acre gave near maximum yields in every case. The higher rates of nitrogen resulted in excessive vegetative growth and water stress, thereby reducing the yield. Table 13 shows the ability of the June water to restore yields above the April-May water treatment, at high nitrogen rates. The magnitude of the response was probably enhanced by the hot June weather.

At maximum yields, no objectionable protein levels were obtained. The test weights were not affected until maximum yields had been obtained.

A dryland wheat yield of 50 bushels was assumed to calculate Table 14. The yield over 50 bushels was divided by the water applied to give the response per inch of water added.

Table 13. Yield, protein concentration and 1970 test weights of Nugaines wheat grown with different levels of N fertilization and supplemental water application. Lind, 1968, 1969 and 1970

Rate of N lbs/a	April			May			April - May			April, May & June		
	1968	1969	1970	1968	1969	1970	1968	1969	1970	1968	1969	1970
						Bu/a.						
0	35	26	75	33	34	78	31	26	89	35	31	104
60	46	31	73	46	41	83	58	53	97	59	53	110
120	51	32	60	48	44	78	68	59	83	71	63	113
180	48	39	62	43	43	77	65	60	79	68	64	102
240	49	45	59	45	36	75	64	53	67	72	66	99
300	44	45	62	46	42	73	63	60	69	76	71	97
						% Protein						
0	6.4	12.2	8.3	6.9	11.8	8.1	6.6	11.3	7.8	6.9	10.8	7.5
60	8.8	12.2	10.3	8.0	12.2	9.5	7.3	12.2	9.2	7.8	11.5	7.6
120	10.8	12.3	12.7	11.4	13.2	11.9	8.3	12.2	11.3	9.3	12.2	9.3
180	12.3	12.8	13.5	12.4	12.9	12.5	10.8	12.7	13.2	10.6	12.6	10.4
240	12.5	12.4	14.6	13.6	13.3	12.8	11.8	12.4	13.9	11.6	12.3	11.1
300	13.4	12.0	14.9	13.0	12.8	13.0	12.9	12.7	14.0	12.1	12.3	11.9
						Test Weight						
0			60.6			60.7			60.0			60.0
60			58.0			61.8			60.2			60.3
120			55.9			60.9			57.2			60.4
180			54.6			61.0			54.1			59.7
240			53.9			59.6			51.4			59.1
300			53.2			59.6			52.8			58.1

Table 14. Bushels of response per inch of water above an assumed 50 bushel dryland yield. Lind, 1970.

Rate of N lbs./a.	April	May	April-May	April, May & June
		Bu/a. in over 50 Bu/a.		
0	6.25	7.00	4.88	4.50
60	5.75	8.25	5.88	5.00
120	2.50	7.00	4.13	5.25
180	3.00	6.75	3.63	4.23
240	2.25	6.25	2.13	4.08
300	3.00	5.75	2.38	3.92

Assuming water costs of $2.00 per inch applied (W.S.U. Masters Thesis by James McGrann, 1968), most treatments in this experiment show a profit. Under the experimental conditions in 1970, the greatest returns came when a 4 inch irrigation was applied in the spring, if nitrogen was not mismanaged. If nitrogen was mismanaged, the June irrigation paid returns of about 7 or 8 bushels per inch of water added.

In another experiment comparing 6 inches of fall applied water, post-emergence, against 6 inches of spring applied water, the fall water yield was about 70 bushels per acre against about 75 bushels for the spring applied water. This was a return of about 3.3 bu/a.in. for fall applied water and about 4.0 bu/a.in. for spring applied water. This implies that the 6 inch water application was less efficient than the 4 inch water application, but nevertheless, was profitable.

In other experiments, phosphorus and micronutrients, designed for maximum production, the yields were severely reduced by the failure to apply water in June. The severe water stress caused the yields to fall to 50 bushels per acre with test weights falling into the low forties.

TREES AND SHRUBS FOR DRY-LAND PLANTING

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

Initial observation tests of woody species are carried on at the Soil Conservation Plant Materials Center at Pullman. Secondary tests are carried on cooperatively at experiment stations at Prosser and Lind, Washington, and Moro, Oregon. 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 slower growing, but is hardy and makes a good dense hedge. Nanking cherry and blue leaf honeysuckle show good promise for the windward row. Where a taller shrub is desired, Russian-Olive appears to be the best adapted shrub, although a wild crabapple 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 Locust	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.