Dry Land Research Unit

51st FIELD DAY

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 existence of certain problems, which, because of special conditions such as climate, soil, etc., cannot be studied at a central station." For fifty years this station has followed this policy of studying the problems associated with the 8 inches 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.

During the station's first 12 years, average precipitation was 8.3 inches, about 2 inches less than the 50-year average. Turkey wheat averaged 15.4 bushels per acre when it was grown during this period. Only three times, 1923, 1927, and 1928, did the yield exceed 20 bushels per acre. Baart spring wheat averaged 13.4 bushels for this same period. By comparison in 1950-63, Turkey averaged 29.2 bushels per acre, and Burt 35.9 bushels. Baart averaged 9.3 inches during this period. The yield difference reflects technological advances in farming of the area more than the slightly higher rainfall.

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. These two hard red winter varieties were released in 1965.

Since 1916 an annual field day has been held to show farmers and interested businessmen the research on the station. This year marks the 51st 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. Forty year average temperature and precipitation at Dry Land Research Unit, Lind.

Month	Temperature °F.			Precipitation
	Max	Min	Mean	40 yr. av. (in.)
January	34	22	28	1.07
February	42	24	33	.91
March	53	32	42	.72
April	63	35	49	.62
May	72	42	57	.77
June	83	45	64	1.00
July	90	52	71	.21
August	90	50	70	.30
September	79	45	62	.60
October	65	38	52	.96
November	47	29	38	1.12
December	37	26	31	1.23
				9.51

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 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, 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 Dryland Research Unit will determine the value of any new selection for the Big Bend Area.

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. This involves the screenings of at least 8 plants per line or a total of over 64,000 plants each year. 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 fifth generation are now in the yield test stage with about 400 lines in rod row trials. About one third of these are red wheat, and the rest are white since most of the snow mold resistance sources are white wheat. 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 three years these varieties were the highest yielding in the regional tests. A summary of these yields are given in Table 2.

Table 2. Yield of selected hard red winter varieties in the western regional hard red winter trials 1964 -66.

Variety	1964 22 locations	1965 17 locations	1966 22 locations	Average 3 years	% Turkey
McCall	47.1	63.5	45.1	51.6	121
Wanser	47.7	60.5	46.3	51.4	120
Cheyenne	43.1	56.7	42.3	47.3	110
Itana 65	46.1	53.2	42.7	47.3	110
Itana	40.7	52.7	40.6	44.7	104
Turkey	38.6	52.7	37.5	42.9	100

Wanser and McCall are widely adapted as shown by the regional tests. The varieties yield well under both dry conditions, intermediate rainfall, and high rainfall or irrigation. The results of these tests at locations in Washington, Oregon, and Idaho are listed in Table 3.

Table 3. Yield of selected varieties at low rainfall, intermediate rainfall, and under irrigation in Washington, Oregon, and Idaho 1964-66.

	Location and Rainfall					
Variety	Lind 9.5"	Moro, Ore. 11"	Pomeroy 14"	Pendleton 14"	Aberdeen Irrigation	Ave.
McCall	41.3	36.8	65.3	61.8	91.2	59.3
Wanser	39.9	41.2	66.1	60.2	95.7	60.6
Cheyenne	38.8	37.5	63.0	52.8	73.6	53.1
Itana 65	39.3	37.4	59.4	52.4	76.9	53.1
Itana	37.7	36.3	53.5	50.5	81.1	51.8
Turkey	36.2	29.5	56.4	49.6	66.1	47.6
Gaines	41.8	39.3	62.6	69.5	88.1	60.3
Moro	41.3	37.3	59.9	60.8	----	----
Burt	39.7	39.4	54.5	61.3	----	----
Omar	39.8	39.5	61.2	54.8	----	----

Wanser and McCall have been the highest yielding variety in Southern Idaho dry land area as well as under irrigation. In Washington good yield data under irrigation for McCall and Wanser is lacking. Yields of 90 to 110 bushel were reported under irrigation last year for Wanser and McCall for seed production. Wanser and McCall are not recommended for irrigation in Washington. The yield potential is less than Gaines or Nugaines in Washington under irrigation. The outstanding yield record at Aberdeen and Twin Falls under irrigation is probably due to better winter survival than Gaines in Southern Idaho.

Wanser and McCall should be adapted to any area now growing hard red winter or Burt in the Pacific Northwest and may be more profitable to grow in some areas now growing white wheat.

Both varieties have good bread quality at protein levels of 11 or above, and are equal to any other hard red at lower protein content for blending with higher protein wheat. Protein content is similar to Itana and Burt--under the same growing conditions.

New varieties better than Wanser and McCall are on the way in the continuous process of improvement through breeding at the Dry Land Research Unit.

Tables 4, 5, 6, and 7 compare the agronomic characteristics of selected winter wheat varieties at four locations. In areas of 11 to 12 inches of rainfall, Gaines is the highest yielding. Gaines has been outstanding at Harrington. At Waterville, Gaines yields have been reduced by snow mold. Wanser and McCall are the two highest yielding hard red winters. Three years of data on Moro indicate a yield potential similar to Omar. Burt has been a consistently high yielding variety at all locations.

Table 4. Summary of agronomic characteristics of winter wheat varieties grown near Harrington in rod row plots 1952 - 66.

Variety	Plant ht.	Test wt.	1966 yield bu/a	Average yield bu/a	Yield % Kharkof	No. Years grown
Gaines	28	59.7	41.8	51.2	130	6
Nugaines	26	62.0	44.0	44.5	129	2
McCall	32	62.4	42.4	44.2	128	2
Moro	38	59.2	38.3	45.8	124	3
Burt	33	61.2	40.4	46.9	123	14
Elgin	35	60.4	35.5	45.1	119	14
Wanser	32	61.8	41.5	40.3	117	2
Omar	38	59.5	34.7	44.6	116	10
Brevor	33	61.1	36.8	43.6	114	14
Itana	37	61.7	37.4	41.6	110	13
Kharkof	39	61.5	34.3	38.1	100	14

Table 5. Summary of agronomic characteristics of winter wheat grown at Lind in rod row nurseries, 1950 - 66.

Variety	Plant ht.	Test wt.	1966 yield bu/a	Average yield bu/a	Yield % Kharkof	No. Years grown
Gaines	26	60.3	44.8	44.2	130	7
Nugaines	23	62.3	44.4	39.0	127	2
McCall	31	61.7	42.9	44.6	124	5
Burt	30	60.9	40.6	36.4	121	12
Wanser	32	61.3	43.4	42.9	119	5
Moro	27	58.3	50.3	41.5	119	3
Cheyenne	32	61.4	40.8	37.4	114	9
Omar	31	59.3	45.6	36.3	113	9
Brevor	28	60.4	38.7	31.9	110	16
Itana	32	61.6	38.8	33.4	109	12
Rio	31	61.8	36.3	29.1	101	15
Kharkof	31	60.8	35.0	28.7	100	16

Table 6. Summary of agronomic characteristics of winter wheat varieties grown near Water ville in rod row nurseries, 1951 - 65.

Variety	Plant ht.	Test wt.	1965 yield bu/a	Average yield bu/a	Yield % Kharkof	No. Years grown
Gaines	27	60.8	46.4	49.4	132	5
Nugaines	28	61.7	49.3	49.3	132	1
Wanser	34	62.4	47.2	45.7	126	2
Moro	34	59.5	46.7	46.7	125	1
McCall	34	60.9	46.1	46.1	124	1
Brevor	31	61.0	48.9	38.9	121	11
Burt	32	61.3	45.4	39.2	120	10
Omar	33	59.7	43.9	39.6	120	9
Cheyenne	37	61.7	47.6	40.9	117	7
Itana	37	61.9	41.6	38.8	114	10
Columbia	34	61.4	40.2	37.0	113	11
Rio	35	61.9	36.9	33.0	102	12
Kharkof	37	61.7	37.3	33.6	100	10

Table 7. Summary of average agronomic characteristics of winter wheat varieties grown in the Horse Heaven Hills in rod row nurseries, 1951 - 66.

Variety	Plant ht.	Test wt.	1966 yield bu/a	Average yield bu/a	Yield % Kharkof	No. Years grown
Moro	17	55.0	17.6	17.6	136	1
Wanser	24	58.2	14.3	19.5	118	2
Omar	24	57.9	14.5	22.3	118	7
Cheyenne	28	59.4	11.6	21.2	115	7
Burt	26	58.6	15.0	22.0	115	8
Itana	28	60.2	15.2	21.4	113	9
McCall	24	57.8	16.6	18.7	113	2
Gaines	21	57.5	17.1	20.5	107	4
Rio	27	60.1	13.7	19.3	101	9
Kharkof	29	59.7	12.9	19.1	100	9

Table 8 summarizes the agronomic data of winter wheat varieties grown in field plots are planted and harvested with conventional equipment and compare more accurately with farmers' fields. Of varieties tested two or more years, McCall, Gaines, Burt, Omar, Moro, and Wanser were the best yielders. Part of the good yield record of McCall is attributed to its outstanding emergence characteristic from deep seeding.

Table 8. Summary of agronomic data for winter wheat varieties grown at the Dry Land Research Unit in drill strip plots, 1950 - 66.

Variety	+ or - Kharkof date head	+ or - Kharkof ht.-in.	Winter* hardiness	Stripe* rust	Av yield bu/a	Yield % Kharkof	Test wt.	No. yrs. grown
Moro	+3	0	6	1	39.2	125	59.1	2
McCall	-1	-4	3	5	37.8	124	62.3	3
Nugaines	+3	-10	5	3	37.5	123	61.9	2
Gaines	+3	-12	5	3	41.4	120	60.9	7
Burt	-1	-4	4	6	36.3	117	61.2	12
Omar	-5	-5	6	8	41.5	117	59.1	9
Wanser	-2	-2	2	3	39.0	116	61.5	4
Cheyenne	-1	-2	1	4	35.5	111	61.1	10
Itana	-1	0	2	8	34.2	109	61.6	11
Brevor	+2	-4	5	3	32.2	109	60.3	14
Itana 65	-1	0	2	3	31.3	100	61.9	2
Kharkof	0	0	1	4	29.7	100	60.8	15
Rio	+1	-1	1	4	28.7	97	60.6	15
Columbia	-3	-4	1	9	29.3	94	61.3	12

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

NEW WHEAT VARIETIES

MORO

Released in 1965, Moro is a back cross variety developed from the cross PI 178383 x $Omar^2$, developed by C. R. Rohde, Pendleton Experiment Station. It is immune to smut and stripe rust strains now present in Washington, but will take some flag smut. It is similar to Omar in yield, but is somewhat poorer in flour quality. It is less lodging resistant than Omar and shatters somewhat more. Moro has good emergence from deep seeding, is similar in winter hardiness to Omar, and is about 4 to 5 days earlier. With three years of testing, it appears that Moro will be similar to Omar in most agronomic respects in the low rainfall area. Moro has a tendency for excessive fall growth in early seeding.

NUGAINES

Nugaines is a sister selection to Gaines, developed by O. A. Vogel, ARS, Pullman. It has only been tested two years in the low rainfall area, but from extensive testing in the high rainfall area, Nugaines is very similar to Gaines. Nugaines has better milling quality than Gaines, and this was one of the main reasons for its release. It has a similar yield, height, winter hardiness, shatter resistance and maturity date as Gaines. It is slightly more stripe rust resistant than Gaines. Nugaines has the same high temperature dormancy problem and poor emergence characteristics that are associated with Gaines. Nugaines is very susceptible to snow mold like Gaines. Nugaines is recommended to replace Gaines.

ITANA 65

Itana 65 is a selection from Itana, made by W. K. Pope, University of Idaho, that has good mature plant resistance to stripe rust. It has good emergence, winter hardiness, quality, and similar maturity to Itana. In three years of trials at Lind and in the low rainfall area of the Pacific Northwest, it has not yielded as well as Itana or Cheyenne, and is definitely lower yielding than McCall or Wanser. It is not recommended for eastern Washington.

WANSER

Wanser was developed at the Dry Land Research Unit from a cross of Burt x Itana. It is a high yielding hard red winter variety. Wanser is shorter than Itana, but taller than Burt. It has more straw strength than Itana, but will lodge somewhat more than Burt. It is as winter hardy as Itana, emerges better from early deep seeding and has quick spring recovery. It is one day earlier than Itana.

Wanser is resistant to all of the common bunt races, the prevalent dwarf bunt races in Washington, and is resistant to flag smut. It is susceptible to some races of dwarf bunt. Wanser has good mature plant resistance to stripe rust, but is susceptible in the seedling stage. It is similar to Nugaines in stripe rust resistance. Wanser is susceptible to foot rot and snow mold. Wanser has good quality.

Wanser will be recommended for the low rainfall area, 8 to 11 inches, of eastern Washington not normally affected by snow mold.

McCALL

McCall is a hard red variety developed at the Dry Land Research Unit from the same cross as Wanser. It is a good quality, high yielding wheat. Shorter than Itana and slightly taller than Burt, it has good lodging resistance. It is more winter hardy than Burt, but less hardy than Itana.

McCall has the same smut resistance as Wanser and Burt, except flag smut resistance. It recovers from light infections of snow mold better than Itana, Burt, Wanser, or other hard red varieties. McCall is not resistant to snow mold and its tolerance is of questionable value. McCall has only fair mature plant resistance to stripe rust. It is better than Burt, but inferior to Wanser. McCall has very good, quick emergence from deep seeding.

McCall is recommended for the northern area of eastern Washington where early seeding and snow mold is a problem. Stripe rust is less serious in this area, and McCall is somewhat higher yielding than Wanser.

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, the highest yielding winter wheat, for the period of 1957 - 66 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 9 shows the yield of standard spring wheat varieties and two new selections at four locations. Marfed is the highest yielding variety at all locations. The two new selections are equal to Marfed in yield for the years grown. They are both hard white wheat varieties with good bread flour quality.

Idaed x Burt 42-5 is a selection from Pendleton Experiment Station developed by Dr. C. R. Rohde. A small initial seed increase was planted for harvest this fall. Both this selection and Burt x Onas 52-466, developed at this Research Unit, are potentially good varieties and are being considered for release. At the present time it appears more likely that Idaed x Burt 42-5 will be released.

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

Variety	Lind--16 yrs. Bu. acre	% Baart	H. Heaven--15 yrs. Bu. acre	% Baart	Waterville--15 yrs. Bu. acre	% Baart	Harrington--16 yrs. Bu. acre	% Baart
Marfed	24.5	112	19.9	109	31.9	116	31.8	115
Lemhi	21.5	99	18.6	102	29.8	109	30.0	109
Federation	22.9	105	18.4	101	29.1	107	28.3	103
Idaed	21.6	99	18.4	101	27.8	102	30.6	111
Baart	21.8	100	18.2	100	27.4	100	27.6	100
Henry	19.0	87	17.5	96	24.2	88	28.8	104
Idaed x Burt -42-5	26.6	110	15.2	102	30.9	113	30.0	110
Burt x Onas 52 -466	27.6	116	15.5	111	30.0	109	30.3	116

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.

Snow Mold

Snow mold is a serious disease on winter wheat in Douglas county and surrounding area where snow cover over long periods are common. A project to study the disease was initiated in 1960 with a grant from the Washington Wheat Commission. Under their continued support this project has advanced from a stage of little knowledge to a stage where successful breeding for resistance will become a reality in the near future. Dr. G. W. Bruehl is project leader, with the breeding work at the Dry Land Research Unit and Agronomy Department. In 1967 a publication, "Snow Molds of Winter Wheat in Washington," by G. W. Bruehl, and others, summarizes all the work to date. It is available at your County Agent's office.

The breeding for resistance is now progressed to yield and quality testing stage. Over 500 selections are under yield test this year at Lind. These were screened for stripe rust and within 5 years the best lines could be available to farmers. If further breeding is necessary, then several more years will be necessary to produce a resistant variety. Some compromise on quality, yield, and other agronomic characteristics may be made on the first varieties released in order to speed up the first resistant varieties. Breeding will continue to improve snow mold resistant varieties so that they will be truly competitive.

Foot Rot Diseases

There has been a general increase in damage from the foot rot diseases in the low rainfall area. Cercosperella foot rot (straw breaker) is the most widespread. Fusarium sp. foot rot is serious in isolated fields, especially in some very early seeded fields. Dr. G. W. Bruehl and Dr. James Cook, WSU plant pathologists, are project leaders in these diseases, with the Dry Land Research Unit cooperating.

Contributing factors to foot rot are early seeding with cool wet spring conditions. Under heavy infection conditions, spring tillage greatly increases the amount of straw breaker foot rot. In 1963, trials with different methods of fertilizer applications demonstrated that spring shanking of fertilizer decreased yield by 10 bushels per acre compared to fall shanking. Pre-plant fertilizing was the least damaged by foot rot. Application of nitrogen fertilizer did not increase foot rot. Nitrogen fertilizer increased the yield of wheat in both inoculated and disease-free wheat. The unfertilized wheat was as equally infected by foot rot as the fertilized wheat.

Cercosperella foot rot can reduce the yield of wheat measureably in light infections. In 1964 and 1965 tests, inocualted wheat was only lightly infected. Under conditions where infection was barely visible, yield reduction averaged 10 to 20% among 10 varieties tested. Under light infection variety differences were not very great. This indicates that foot rot diseases are causing more yield loss than is generally attributed to these diseases.

The world collection of winter wheat varieties has been screened for resistance. Some resistance is present in several varieties. Crosses to these varieties have been made and will be selected for tolerance to foot rot. Evidence indicated that crosses between two susceptible varieties may give lines with more resistance than either parent. Segregating population of most crosses will be tested under disease conditions for the most tolerant lines.

From the data now available these recommendations can be made for areas that have a history of foot rot. Gaines, Nugaines, Omar, and Moro are the best commercial varieties to seed. Avoid seeding foot rot areas extremely early. Delay seeding as long as possible in deep seeding, but seeding should be done when moisture is adequate for a good stand. Early seeded diseased wheat often outyields late seeded wheat that escapes disease.

In the low rainfall area, nitrogen fertilizer should be applied pre-plant. Spring tillage with fertilizer shanks, rotary hoe, skew treader or harrow all tend to increase infection in fields infected with foot rot.

Stripe Rust

The potential for a serious stripe rust epidemic has been present almost every year since 1962. During these years stripe rust was serious in certain relatively small areas. Unfavorable dry spring weather or heavy winter injury to leaves has kept the disease from spreading in epidemic proportions. In 1966-67 the conditions were right, and an infection of serious proportions developed.

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 three years over 18, 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 very effective or economical. Two new chemicals show some promise. N-3412 and Plantvax are effective in trials this year, and N-3412 has been effective in Oregon trials. Wide scale testing of Plantvax this year will determine to a large degree if this chemical will have possible use as a systemic protection to stripe rust. Neither of the chemicals are available or registered for use on wheat.

The most effective control of stripe rust is through resistant varieties. Of the commercial varieties, Moro is resistant. Nugaines, Brevor, Gaines, Wanser, Cheyenne, McCall, and Burt are recommended varieties which have mature plant reistance. McCall and Burt have 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. L. H. Purdy, ARS Plant Pathologist, and Dr. R. A. Allan, ARS, Plant Breeder. The overall program includes epidemiology studies, biological race studies, evaluation for variety resistance breeding.[1]

Cultural Practices for Dry Land Wheat Production

Successful cultural practices in dryland wheat production are those which make optimum use of our limited moisture. Practices which allow maximum intake of precipitation and tend to limit evaporation or loss during the summer fallow year are essential. Timely seeding, proper fertilization, and use of adapted varieties all enter into the picture. This discussion is concerned with the factors other than variety, fertilizer, and diseases that effect wheat production.

Eastern Washington has a winter rainfall pattern. Over 80% of the moisture occurs from November through May. This is primarily the time of maximum winter wheat growth. Transpiration is less during these months than during June and July. Accelerating growth during the cool season uses moisture more efficiently. Cultural practices should be designed to save as much as possible of the moisture that comes and then to use it with maximum efficiency.

Conservation of moisture should start as soon as the crop is harvested. The stubble should be worked immediately if an active weed growth occurs. These weeds are removing deep moisture that will be needed by the next crop. In the 8" to 12" areas, sweeping at a depth of 4" to 5" will usually kill these weeds--provided there is enough overlap in the sweeps. This often leaves the

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[1] Stations Circular 424, Stripe Rust, What It Is and What To Do About It, is available at your county extension office. This is an excellent review of the stripe rust problem by Dr. Hendrix.

soil somewhat pulverized, and a fall chiseling after rain to a depth of 8 inches will help put the soil in a rough condition to take up moisture when the soil is frozen during the winter. In the northern areas, where snow is expected to accumulate and the soil freezes deep, chiseling to depths of 10-15 inches helps the intake of moisture. 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. 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.

Initial summerfallow operation should be one to kill volunteer and weed growth and work up a mulch for the following operations. Enough stubble should be left on the surface to protect against wind erosion if possible. Depth of tillage has not been adequately determined and will vary with area and soil type. Temperature appears to be a very important factor in how deep the soils need to be worked. In areas of cooler temperatures, shallower tillage depth is more effective than in areas where summer temperatures are higher.

After the initial tillage with a sweep, offset disc, or similar implements; skew treading with the teeth in packing attitude has helped firm up the soil, break up heavy straw, and kill small weed growth. Usually rod weedings after these two operations is all that is necessary for weed control. In light sandy soils the skew treading may be too severe, and the rod weeder may be the only tool to use after initial tillage. Rotary hoes pulled backward or discs pulled with a small cutting angle are also effective in firming up the soil after initial tillage. Successive rod weeding should be frequent enough for weed control only. However, fields should not be allowed to green up before weeding. When weeds get that large, they are using moisture rapidly.

Fertilizer application will have an effect on soil moisture. Unless fertilizer is applied immediately before seeding, the application should be made early in the summerfallow season, before soil temperatures are high, to prevent moisture loss. Applications timed previous to a normal weeding operation will disturb the soil moisture less than if the fertilizer operation is not followed by a weeding. High rates of fertilizer application at seeding time should be made across the direction of seeding to prevent placing seed in fertilizer shank marks. High concentrations of either nitrogen or phosphorous in the seeding zone can affect germination.

Studies at the Dry Land Research Unit since 1959 have shown that date of seeding with adequate fertility level is the most important factor affecting yield of wheat. The results of a 3-year trial are shown in Table 10. The lowest yield was without nitrogen fertilizer at the late date of seeding. The highest yield was with 60 pounds of nitrogen at the early date of seeding. Fertilizer response was greater at the earlier dates of seeding.

Table 10.

Rate of Nitrogen	Average Yield Increase Bu/A					
	Oct. 15		Sept. 15		Aug. 20	
	Burt	Itana	Burt	Itana	Burt	Itana
0#, Check	0	0	2.7	4.3	9.1	7.1
30#, Summerfallow	4.5	3.4	9.1	9.1	16.1	11.5
30#, Sidedress, Spring	4.4	1.4	11.5	7.7	15.4	11.5
60#, Summerfallow	7.1	3.5	13.0	12.2	17.4	13.0
Check yield	25.3	24.8	28.0	29.1	34.4	31.9

Table 11.

Seeding Date	Nitrogen Applied lbs/A	Soil Moisture Used		Yield	
		Gaines	Omar	Gaines	Omar
		inches	inches	Bu/A	Bu/A
Early (9-7)	0	4.0	5.5	18	18
	35	5.8	6.0	33	28
	70	5.8	6.3	36	29
Late (10-16)	35	6.6	6.4	33	21
	70	7.3	6.7	35	21

In Table 11, the total soil moisture usage at two dates of seeding are given. Fertilizer increased the amount of moisture used by both Omar and Gaines. More moisture was used by the late seeded wheat than early seeded wheat at the same fertilizer rate. Early seeding produced more wheat with less total moisture at the same level of fertility.

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 high 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 tissue. Early seeded wheat is in a more advanced stage when high temperatures occur resulting lower moisture requirements. 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. Research was conducted to determine if wider spacings would affect yield. Data presented in Table 12 show the results of these trials at Lind. Results from this study and another trial at Dusty show row spacings up to 20 inches will not decrease yield of wheat in the yield 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.

Table 12. Average yield of Gaines wheat seeded at different row spacings and rates, and dates at Lind 1962-1965.

Row Spacing	Date	Seed Rate	1962	Year 1963	1964	1965	Av Yield	Av Both rates
7"	Late*	60#		31	33	25	29.7	
7"	Late*	45#		30	35	25	30.0	29.8
14"	Early**	60#	45	32	35	32	36.0	
	Early	45#	44	27	37	35	35.8	35.9
14"	Late	60		31	34	36	30.3	
14"	Late	45		30	35	23	29.3	29.8
20"	Early	45	49	28	34	35	36.5	
20"	Early	34	47	27	34	34	35.5	36.0
20"	Late	45		31	34	26	30.3	
20"	Late	34		30	35	23	29.3	29.8
28"	Early	45	43	23	32	34	34.0	
28"	Early	34	43	24	32	35	34.5	33.3

*Late date Oct 15 - Nov 15
**Early date Sept 10-20

In summary, tillage should be designed to allow free penetration of water during the winter following harvest. During the summerfallow 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. Research to find out more about the factors that influence moisture retention in our soils is being studied under a grant by the Washington Wheat Commission (reported in the next section). With this detailed information, better programs for tillage will be planned to hold the summerfallow moisture in the seeding zone. Until this information is available, the following program of stubble mulch tillage is recommended for the 8 to 11 inch rainfall 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 to a 5"-6" depth with sweep, offset, or heavy disk, or narrow spaced chisel points.

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. Deeper mulches are recommended for areas of high summer temperatures.

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

6. Deep furrow seeding of recommended variety starting approximately August 20 in Douglas County, September 1, 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.

Soils Project

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." Project leaders are Dr. F. E. Koehler and W. L. Nelson, with Dr. W. Gardner cooperating. Mike Lindstrom was employed in March 1967 to work full time on this project.

The purpose of the project is to find the combination of tillage practices which will provide the maximum moisture for the wheat crop with special emphasis on maintenance of a good soil moisture level in the seeding zone. This would increase the maximum 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.

A well has been drilled and an irrigation system is being developed, so that the influence of different levels of soil moisture and moisture conservation after a summer rainfall can be studied.

The evaluation of soil moisture levels in the seeding zone will be made using radio active techniques. This will be related to the density or compaction of the soil as it is changed by different tillage practices.

An undisturbed block of soil will be taken to the laboratory at the station headquarters building. It will be placed between a source of gamma rays (Cesium 137) and a gamma ray detector. The amount of reduction of gamma radiation by the soil block plus the moisture in it is proportional to the total density of the block. Therefore, the density can be calculated for the soil at any depth. The block of soil will be dried in an oven and the density is again determined at any point in the profile represented by the block of soil brought into the laboratory.

Total moisture in the soil profile, its movement in the soil, and the pattern of use by the growing wheat is being studied by other nuclear techniques. Aluminum tubes have been placed in the soil down to a depth of seven feet. A neutron soil moisture probe is then lowered into the aluminum tube and moisture measurements are taken at one-foot intervals. From this the total moisture content can be measured in the soil profile, plus, from successive measurements, the movement of water can be observed.

In addition to these studies, other factors affecting soil moisture levels in the speeding zone such as depth of dry soil mulch on the soil surface and soil temperature are being studied.

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 35 years old. Plantings have been made at intervals since the original planting. The Station planting is one of the best in the West for studying trees and shrubs adapted to dry land conditions. Stations Circular 450, 1965, summarizes the adaptation tests of trees and shrubs for the intermountain area of the Pacific Northwest.

Initial observation tests of wood species are carried on at the Soil Conservation Nursery at Pullman. Secondary tests are carried on cooperatively at experiment stations at Prosser and Lind, Washington, Moro, Oregon. 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.

A standard dry land windbreak planting consists of a minimum of three rows. When properly established, these give excellent protection from the winds. Results to date indicate the Caragana is still the best erect shrub. Blue leaf honeysuckle, Nanking Cherry, and Bladder Senna are showing considerable promise. Bladder Senna had considerable winter kill in 1965. Russian olive is the recommended species of intermediate shrub. Hawthorn and a strain of wild crabapple are showing promise.

Black locust is still the best deciduous tree. Green ash and Chinese elm may be used, but they are not as good as black locust. Austrian pine is the outstanding evergreen tree, being superior to both Scotch and Ponderosa pine. Douglas fir and Blue spruce can be grown but require more care and grow much slower. Rocky Mountain juniper is an outstanding medium height evergreen. Rocky Mountain juniper is more difficult to establish than other evergreens, but is extremely hardy and vigorous once established.

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

Table 13. 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	Evergreen	12 ft.	27 ft.

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