Dry Land Research Unit
52nd 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 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 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 1 inch less than the 47 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 20 bushels and Marfed 23.4 over the same period. Rainfall 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. Over 400,000 acres of these two varieties were planted in 1966 reversing the downward trend of hard red winter wheat acreage.

Since 1916 an annual field day has been held to show farmers and interested businessmen the research on the station. This year marks the 52nd 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 concides 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. Max	Min	Mean	Precipitation 47 yr. av. (in.)
January	34	22	28	1.02
February	42	24	33	.90
March	53	32	42	.72
April	63	35	49	.63
May	72	42	57	.77
June	83	45	64	.96
July	90	52	71	.22
August	90	50	70	.30
September	79	45	62	.56
October	65	38	52	.90
November	47	29	38	1.23
December	37	26	31	1.26
				9.47

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

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, 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 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 sixth generation are now in the yield test stage with about 50 lines in rod row trials, in their second year of yield testing. 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 four years these varieties were 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 in Table 2. 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 in the higher rainfall areas. Table 3 gives the yields under the lower rainfall areas of Washington and Oregon.

Table 2. Yield of selected hard red winter varieties in the western regional hard red winter trials 1964-67.

Variety	1964 22 locations	1965 17 locations	1966 22 locations	1967 21 locations	Average 4 yrs.	% Turkey
McCall	47.1	63.5	45.1	47.5	50.8	120
Wanser	47.7	60.5	46.3	48.6	50.8	120
Cheyenne	43.	56.7	42.3	43.4	46.4	109
Itana 65	46.1	53.2	42.7	43.6	46.4	109
Itana	40.7	52.7	40.6	39.0	43.3	102
Turkey	38.6	52.7	37.5	40.8	42.4	100

Table 3. Yield of selected varieties in low and intermediate rainfall areas in Washington and Oregon, 1964-67.

Variety	Location and Rainfall				
	Lind 9.5"	Moro, Ore.* 11"	Pomeroy 14"	Pendleton 14"	Average
Gaines	43.5	37.0	66.7	69.8	54.3
Wanser	41.0	37.3	62.1	61.6	50.5
Moro	44.8	36.6	60.9	59.6	50.0
McCall	41.2	34.2	61.6	62.0	49.8
Cheyenne	38.8	34.3	60.2	53.6	46.7
Burt	39.1	34.2	52.8	58.8	46.2
Itana 65	38.4	33.5	58.5	52.0	45.6
Omar	37.7	33.7	55.0	52.9	44.8
Itana	34.9	33.2	52.9	48.0	42.3
Turkey	36.7	27.7	54.4	49.5	42.1
Station Av.	39.6	34.2	58.5	56.8	47.2

*Moro location 3 years, 1965 missing.

Wanser and McCall have not been tested extensively under irrigation. In southern Idaho, both varieties have performed very well under both dry land and irrigation and are recommended for that area. Yields under irrigation at Twin Falls and Aberdeen are listed in Table 4. Gaines was not included in all of these trials, however yields of Wanser and McCall were similar to Gaines in the years tested at these two locations under irrigation. In Washington yields of 90 to 110 bushels per acre under irrigation for McCall and Wanser were obtained during initial seed increase. These are the first hard red varieties consistently yielding near 100 bushels per acre under irrigation. However, the yield potential of Nugaines and Gaines is greater under high rainfall or irrigation than Wanser and McCall.

Table 4. Average yield of selected hard red varieties grown under irrigation at Aberdeen, and Twin Falls, Idaho, 1964-67.

Variety	Aberdeen	Twin Falls	Average
McCall	89.7	90.2	90.0
Wanser	93.6	84.5	89.5
Itana	78.1	80.3	79.2
Itana 65	78.0	78.1	78.1
Cheyenne	73.1	70.8	72.0
Turkey (Kharkof)	66.8	63.2	65.0

McCall and Wanser are adapted to areas now growing hard red winter or Burt in the Pacific Northwest. Due to price differential often paid hard red winter wheat, and the rapidly expanding overseas market for this class of 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 5, 6, 7, and 8 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 9 gives the data from large scale field plots at Lind. Data from these trials and other large scale field plots in eastern Washington are used to make variety recommendations.

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

Table 5. Summary of agronomic characteristics of winter wheat varieties grown near Harrington in rod row plots 1952-67.

Variety	Plant ht.	Test wt.	1967 yield bu/a	Average yield bu/a	Yield % Kharkof	No. Years grown
Nugaines	26	62.2	51.1	46.7	147	3
Wanser	32	62.1	51.1	43.9	138	3
Gaines	28	59.9	44.9	50.3	134	7
McCall	32	62.7	38.9	42.4	134	3
Moro	38	59.6	41.7	44.8	130	4
Burt	33	61.4	33.0	46.0	123	15
Elgin	35	60.6	26.1	43.8	118	15
Omar	38	59.8	26.4	42.9	115	11
Kharkof	39	61.6	26.1	37.3	100	15

Table 6. Summary of agronomic characteristics of winter wheat grown at Lind in rod row nurseries, 1950-67.

Variety	Plant ht.	Test wt.	1967 yield bu/a	Average yield bu/a	Yield % Kharkof	No. Years grown
Gaines	26	60.5	48.8	44.8	129	8
Nugaines	25	62.2	53.1	43.7	125	3
Moro	30	58.6	55.5	45.0	125	4
McCall	31	61.9	41.3	44.1	119	6
Burt	30	61.0	37.2	36.5	118	13
Wanser	32	61.5	44.2	43.2	117	6
Cheyenne	32	61.5	38.7	37.5	113	9
Omar	31	59.4	31.2	35.8	109	10
Itana	32	61.6	26.7	32.9	106	13
Kharkof	32	60.9	39.3	19.3	100	17

Table 7. Summary of average agronomic characteristics of winter wheat varieties grown in the Horse Heaven Hills in rod row nurseries, 1951-67.

Variety	Plant ht.	Test wt.	1967 yield bu/a	Average yield bu/a	Yield % Kharkof	No. Years grown
Moro	17	55.7	13.0	15.3	121	2
Wanser	23	59.4	14.3	17.8	117	3
Omar	23	57.7	10.8	20.9	116	8
Cheyenne	27	59.6	13.8	20.2	115	8
Burt	25	58.9	14.2	21.1	114	9
McCall	23	59.3	13.8	17.1	113	3
Itana	28	60.4	11.9	20.5	112	10
Gaines	20	58.2	13.7	19.1	108	5
Kharkof	28	59.7	12.3	18.4	100	10

Table 8. Summary of agronomic characteristics of winter wheat varieties grown near Waterville in rod row nurseries, 1951-67.

Variety	Plant ht.	Test wt.	1967 yield bu/a	Average yield bu/a	Yield % Kharkof	No. Years grown
Nugaines	28	63.0	73.7	61.5	145	2
Gaines	27	61.2	75.2	53.7	139	6
Burt	33	61.5	62.9	41.4	125	11
McCall	36	62.7	57.5	51.8	124	1
Wanser	36	63.0	59.9	50.4	122	3
Moro	38	60.2	55.7	51.2	121	2
Omar	34	59.9	56.2	41.3	120	10
Cheyenne	38	62.0	55.1	42.7	116	8
Itana	38	62.2	54.1	40.2	113	11
Columbia	34	61.6	47.7	37.9	111	12
Kharkof	38	61.9	44.1	34.1	100	11

Table 9. Summary of agronomic data for winter wheat varieties grown at the Dry Land Research Unit in drill strip plots, 1950-67.

Variety	+ or - Kharkof date head	+ or - Kharkof ht.-in.	Winter* hardi-ness	Stripe* rust	Av yield bu/a	Yield % Kharkof	Test wt.	No. years grown
Moro	+3	0	6	1	41.1	132	58.6	3
Nugaines	+3	-10	5	3	37.5	121	61.4	3
Gaines	+3	-12	5	4	41.3	121	60.7	8
Wanser	-2	-2	2	3	38.6	118	61.6	5
Burt	-1	-4	4	6	35.9	115	61.2	13
McCall	-1	-4	3	5	36.7	115	62.4	4
Omar	+5	-5	6	8	36.3	114	59.0	10
Cheyenne	-1	-2	1	4	35.2	110	61.2	11
Itana	-1	0	2	8	33.5	106	61.6	12
Kharkof	0	0	1	4	29.8	100	60.8	16

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

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

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

The only varieties that are recommended for eastern Washington are Nugaines, Moro, Wanser, and McCall. Gaines is recommended only if seed of Nugaines is not available. For early seeding, year old Gaines seed would be recommended over new Nugaines seed. If in doubt about the variety to seed in your immediate area and soil condition, see your County Agent.

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 1957-67 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 10 shows the yield of standard spring wheat varieties and one new selection at four locations. Marfed is the highest yielding variety at all locations.

Adams, a cross of Idaed x Burt 42-5 is a selection from Pendleton Experiment Station developed by Dr. C. R. Rohde. Since the yield of Adams is not as good as Marfed, and because it is a hard white wheat, it is not recommended for eastern Washington. However, it would be a good variety to reseed into Burt.

Table 10. Yield in bushels per acre and percent of Baart for spring wheat varieties at four locations in rod row plots.

	Lind 17 yrs.		H. Heavens 15 yrs.		Waterville 16 yrs.		Harrington 16 yrs.	
	Bu. acre	% Baart	Bu. acre	% Baart	Bu. acre	% Baart	Bu. acre	% Baart
Marfed	24.1	112	19.9	109	31.5	117	31.3	117
Lemhi	20.9	97	18.6	102	28.9	107	28.9	108
Federation	22.3	104	18.4	101	28.6	106	27.7	104
Idaed (Idaed 59)	21.5	100	18.4	101	27.8	103	30.4	114
Baart	21.5	100	18.2	100	26.9	100	26.7	100
Henry	18.8	87	17.5	96	24.1	90	28.2	106
Adams*	26.6	110	15.2	102	30.9	113	30.0	110

*5 years of data.

The spring wheat breeding program at the Dry Land Research Unit has some promising selections of both red and white spring wheat. None of the red selections have as good quality as may be desired, however, two selections may be acceptable. The white spring wheat selections are stripe rust resistant, good milling types with pastry quality comparable to soft white winter wheat.

Hard Red Spring Wheat

Henry x Burt 65-4 (N6500144) has been yield tested for 5 years. It has an average yield record of 102% of Marfed and in only one of these years did it yield less than 98% of Marfed. It is susceptible to stripe rust with some tolerance to the disease. The yield under stripe rust infection is similar to Marfed which shows about the same amount of infection. It has a similar maturity date as Marfed. Milling score is slightly below Henry, but acceptable. Although the loaf volume is good, the mixing strength is only fair, comparable to Rio winter wheat. This selection appears to be the most promising one for reseeding into winter wheat.

1750/Timstein//Anniverserio Sel. 14 has also been yield tested for 5 years. years. It has an average yield of 93% of Marfed, and 115% of Henry. It is a tall variety with fair stripe rust resistance and matures about the same date as Marfed. This variety has only fair milling quality with lower flour yield, but has excellent strength and loaf volume. It produces a very strong type flour. It would also fit into the reseeding program for hard red winter wheat.

Two selections from the cross W321/2*2173//Onas 52 have been yield tested for three years and average about 110% of Marfed. They are immune to stripe rust, mid tall, and maturity is similar to Marfed. Both have excellent milling scores, but are very weak, and do not make good bread. Their use will be primarily for breeding parents as a source of rust resistance with good milling characteristics and high yield.

White Spring Wheats

The highest yielding white wheat selections are from the parent Koelz 7941 which carries a very good type of stripe resistance. One selection Koelz 7941 x Onas 52 66-9 has an average yield of 125% of Marfed for the last three years. Milling quality is similar to Idaed, but it is a pastry type similar to the soft white winter wheat varieties. The selection is about two days earlier than Marfed.

Five selections from the cross of Kenya 337/Awned Onas//Koelz 7941 have averaged better than 110% of Marfed yield the last three years. These are all stripe rust resistant with milling quality equal or better than Idaed. All are pastry types with good cookie characteristics. They could probably be reseeded into soft white winter. These are the first selections we have developed that have consistently out yielded Marfed.

We have tested, and are continuing to evaluate the recent varieties from the Rockefeller program at CIANO. The varieties are earlier than Idaed under our conditions, and have not been outstanding in yield or quality. A program to evaluate these varieties under different management conditions is planned for the future.

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 successsful 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 Washingtin," by G. W. Bruehl, and others, summarizes all the work to date. It is available at your County Agent's office.

For two successive years we have had no snowmold in field trials in Washington. But field studies were furthered last year through the cooperation of the University of Idaho and the U.S.D.A. At Tetonia the snow melted May 10, 1967. Even under this prolonged snow cover some of our experimental wheats survived. Dr. Huber of the University of Idaho and Dr. Sunderman of the U.S.D.A. cooperated in giving us snowmold readings so the season yielded useful disease data.

Straw strength, stripe rust, yield, and quality data were obtained from the yield plots at Lind by Walter Nelson. Five wheats with satisfactory agronomic characteristics and some degree of snowmold resistance were selected for further trials. Field plots of 1968 promise good agronomic data but no disease ratings. It is essential to know the abilities of these wheats to yield in the absence of disease, so the yields in Washington are important to us.

Again, snowmold was severe at Tetonia but the snow melted even later this year and we don't know the results of the trials in Idaho.

We sincerely appreciate the cooperation of our neighbors in this project.

Foot and Root Rot Diseases

There has been a general increase in damages from foot and root rot diseases in the low rainfall area. Cercosperella foot rot (straw breaker) is the most wide spread. Fusarium sp. root rot is serious in isolated filds, especially in the very early seeded fields. With an increase in recropping of wheat, take all, caused by Ophiobolus graminis, a root rot is on the increase. Dr. G. W. Bruehl and Dr. James Cook are project leaders in the study of these diseases with the Dry Land Research Unit cooperating. A review of all the recent studies on straw breaker (Cercosperella foot rot) was published in 1968 in the

Washington Agricultural Experiment Station bulletin No. 694. This bulletin by Dr. G. W. Bruehl and others. It includes all the data from recent experiments and a complete review of the factors affecting the disease.

The breeding program at the Dry Land Research Unit includes parental material that has tolerance to foot rot. In additional all advanced breeding material is tested under heavy infestations of Cercosperella to evaluate their reaction to the disease.

Dr. James Cook has established a disease nursery for testing for resistance to take all root rot diseases. This disease occurs under continuous cropping to wheat. The new irrigation system at the station makes this work possible. It will include testing of the breeding material from WSU and the station under heavily infested soils.

Testing for resistance to root rots caused by Fusarium sp. is conducted in naturally infested soils. These tests are on the Walt Jantz farm near Ritzville, and are conducted by Dr. Cook and Dr. O. A. Vogel.

From the data now available, these recommendations can be made for areas that have a history of foot rot. Nugaines and Moro are the best commercial varieties to seed. Avoid seeding root rot areas extremely early. Delay seeding as long as possible when seeding deep, but seeding should be done when moisture is adequate for a good stand. Early seeded diseased wheat often out yields late seeded wheat that escapes the disease in the low rainfall areas. Do not side dress fertilize, rotary hoe or skew tread infected areas in the spring. This will greatly increase the damage in areas that are infected.

Stripe Rust

Since 1960 the potential for a serious stripe rust epedemic has been present most of the years. Stripe rust has been serious in certain small areas almost every year, however it caused serious damage in 1960, 61 and 67.

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 very effective or economical. Two new chemicals show some promise. N-3412 and Plantvax were effective in trials last year, and N-3412 has been effective in Oregon trials. 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, 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. A. Allan, ARS. Plant Breeder. The overall program includes epidemiology studies, biological race studies, evaluation for variety resistance breeding.

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.

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 soil somewhat pulverized, and a fall chiseling after rain to a depth of 8" - 12" 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. From data reported later in this write-up, a soil mulch depth of 3 to 5" is necessary to hold moisture in the seedling zone.

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. Application of nitrogen (NH_3) with the drills by shanking in between the rows has been a very effective way of applying fertilizer.

Studies at the Dry Land Research Unit since 1959 have shown that date of seeding with adequate fertility level is one of the most important factors affecting yield of wheat. Early seeding increased the response to fertilizer as well as increasing yield. The highest yields have been obtained by early seeding with 50 to 60 lbs of additional nitrogen.

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 to table 11 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 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.

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 re tention 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.

Table 11. Average yield of Gaines wheat seeded at different row spacings and rates, and dates at Lind 1962-65.

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.

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

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

SOILS PROJECT

Dr. F. E. Koehler and Mike Lindstrom

In 1965 the Washington Wheat Commission began supporting a project to study the "Factors affecting water conservation for plant growth in the low rainfall areas of eastern Washington." Project leaders are Dr. F. E. Koehler and W. L. Nelson with Dr. W. Gardner cooperating. Mike Lindstrom was employed in February of 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 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.

For the 1967 fallow year the fall tillage treatments studied were: (1) Disc at 5-6 inches deep, (2) Chisel at 9-10 inches deep with the chisel points on 12 inch centers, and (3) no fall tillage. Spring tillage treatments studied were: (1) Disc at 5-6 inches deep, (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. Additional plots were set up which received no tillage except for the fall tillage treatment. Weeds were controlled by chemicals.

Fall tillage treatments have had little effect on moisture intake, since there was no runoff from any of the plots. Spring tillage treatments appeared to have little effect on total moisture. No difference in total moisture content could be determined between the regular tilled plots and the none tilled plots, but the none tilled plots had less moisture in the first foot and had a marked reduction of moisture in the seeding zone. The tillage plots were seeded with Wanser on Sept. 18. There was no difference in the rate and amount of emergence between the tilled plots, but the rate was slower and the percent of emergence was less in the none tilled plots.

Tillage treatments for the 1968 fallow year are the same as the treatments above. Three levels of moisture have been set up to enable studies to be made on the effect of moisture levels in the soil in the early spring on the retention of moisture in the soil profile and in the seeding zone during the summer. The moisture levels set up are: (1) natural moisture, (2) natural moisture plus $4\frac{1}{2}$ inches of additional water, and (3) a completely saturated profile.

SOIL MOISTURE AND TEMPERATURE STUDY

Dr. R. I. Papendick

A study was initiated last year (1967) in cooperation with Dr. R. I. Papendick of the Soil and Water Conservation Research Division, ARS, Pullman, to determine the effect of depth of the dry loose layer (dust mulch) created by summer fallow tillage, and straw cover on soil water in the seed zone at seeding time. Three depths of dust mulch and two levels of straw were used in the study. The mulch depths were 2, $3\frac{1}{2}$, and $4\frac{1}{2}$ inches. Straw levels were residual straw from the previous wheat crop and residual straw + 2 tons of additional straw surface applied. Thermocouples to measure soil temperatures were installed in all plots at the bottom of the dust mulch (rod weeding depth), 5, 7, and 12 inches below the soil surface. Soil water content in the top foot of soil was determined by gamma radiation attenuation on blocks of natural soil taken from selected plots, and from core sampling the remaining plots.

Temperature data from the study showed that the soil at seed zone depth was coolest under the deepest dust mulch. Soil water data showed that the water content in the seed zone generally increased with increase in depth of dust mulch. The insulative effect from the additional straw and a corresponding somewhat higher water content in the seed zone was apparent in the 2, and $3\frac{1}{2}$-inch mulch but was not so in the $4\frac{1}{2}$-inch mulch. The results indicate that the thermal insulation effect of the mulch layers may be an important factor in reducing soil water losses, especially in the vicinity of the seed zone.

The plots were seeded to Wanser wheat on September 20. Wheat emergence was most rapid and final stands were complete first on the deep dust mulch plots. Difference in time when emergence first occurred between the shallow and deep mulch plots was about 2 days.

The studies are being continued this year. Depth of loose layers are none, 2, 4, and 6 inches. In addition, 2 levels of soil water have been established which are (1) natural rainfall, and (2) natural rainfall plus 6 inches from irrigation.

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 12. 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.