Dry Land Research Unit

50th 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 to 12" 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 40' 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. A new well to supply 100 gpm of water for irrigation and domestic supply is now being drilled.

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 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.

Since 1916 an annual field day has been held to show farmers and interested businessmen the research on the station. This year marks the 50th field day. During the past 10 years the attendance has averaged over 350. Visitors are welcome at any time and suggestions are welcome.

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 Sept. 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. 40 year average temperature and precipitation at Dry Land Research Unit, Lind.

Month	Temperature °F.			Precipitation 40 year average (in.)
	Max	Min	Mean	
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. Fifty to 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

The breeding program for winter wheat is concentrated on hard red winter varieties. The transfer of snow mold resistance into both hard red and white wheat varieties is receiving most of the emphasis at the present time. Stripe rust, foot rot and smut resistance are also given priority in the breeding program. Tables 2, 3, 4, and 5 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 snowmold. Wanser and McCall are the two highest yielding hard red winters. Two years of data on Moro indicate a yield potential similar to Omar. Burt has been a consistently high yielding variety at all locations.

Table 2. Summary of agronomic characteristics of winter wheat varieties grown near Harrington in rod row plots 1952 - 65.

Variety	Plant ht.	Test wt.	1965 yield bu/a	Average yield bu/a	Yield % Kharkof	No. Years grown
Gaines	28	59.1	39.6	52.8	140	5
Nugaines	24	60.8	44.9	44.9	131	1
McCall	32	61.0	45.6	45.6	133	1
Moro	38	58.9	48.2	49.5	129	2
Burt	33	61.1	41.6	47.4	123	13
Elgin	35	60.3	41.5	45.9	119	13
Omar	38	59.4	41.2	45.6	119	8
Brevor	33	61.0	37.0	44.1	115	13
Wanser	32	61.1	38.8	38.8	113	1
Itana	37	61.6	37.8	41.9	110	12
Kharkof	39	61.4	34.4	38.4	100	13

Table 3. Summary of agronomic characteristics of winter wheat grown at Lind in rod row nurseries, 1950 - 65.

Variety	Plant ht.	Test wt.	1965 yield bu/a	Average yield bu/a	Yield % Kharkof	No. Years grown
Gaines	26	60.0	40.3	44.1	129	6
McCall	31	61.4	38.3	45.0	124	4
Burt	30	60.8	36.1	35.9	121	11
Wanser	32	61.1	36.4	42.8	118	4
Cheyenne	32	61.2	33.0	37.0	116	8
Itana	32	61.4	33.5	32.9	111	11
Omar	31	59.0	30.5	35.2	110	8
Brevor	28	60.2	33.3	31.4	110	15
Nugaines	23	62.3	33.4	33.4	107	1
Moro	25	57.2	30.0	36.9	105	2
Rio	31	61.8	35.5	28.6	101	15
Kharkof	31	60.7	31.3	28.3	100	15
Columbia	29	61.7	29.0	27.9	94.0	11

Table 4. Summary of agronomic characteristics of winter wheat varieties grown near Waterville 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 5. Summary of average agronomic characteristics of winter wheat varieties grown in the Horse Heaven Hills in rod row nurseries, 1951 - 63.

Variety	Plant ht.	Test wt.	Yield bu/a	Yield % Kharkof	No. years grown
Wanser	28	58.2	24.7	121.7	1
Omar	26	58.2	23.6	118.0	6
Cheyenne	30	59.6	22.8	117.5	6
Burt	27	59.0	23.0	114.8	7
Brevor	27	59.0	21.5	113.5	6
Itana	29	60.3	22.1	111.9	8
Columbia	26	61.0	21.1	106.8	8
Gaines	22	57.5	21.6	106.2	3
McCall	26	57.8	20.8	105.1	1
Rio	28	60.4	20.0	101.0	8
Tendoy	29	59.9	19.7	100.3	4
Kharkof	30	60.1	19.8	100.0	8

Table 6 summarizes the agronomic data of winter wheat varieties grown in field plots at Lind. These 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 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 6. Summary of agronomic data for winter wheat varieties grown at the Dry Land Research Unit in drill strip olots, 1950 - 65.

Variety	+ or - Kharkof date head	+ or - Kharkof ht.-in.	Winter* hardiness	Stripe* rust	Av yield bu/a	Yield% Kharkof	Test wt.	No. years grown
McCall	-1	-4	3	5	38.5	129	62.3	2
Nugaines	+3	-10	5	3	38.5	127	61.6	1
Sel. 1	-1	-2	3	4	37.9	125	61.2	1
Gaines	+3	-12	5	3	41.9	120	60.8	6
Sel. 17	-1	-2	3	4	35.8	118	61.0	1
Burt	-1	-4	4	5	36.0	116	61.1	11
Omar	-5	-5	6	8	41.5	116	58.7	8
Wanser	-2	-2	2	4	39.0	115	61.3	3
Cheyenne	-1	-2	1	3	35.6	111	61.0	9
Itana	-1	0	2	7	34.3	109	61.5	10
Brevor	+2	-4	5	3	32.2	109	60.2	14
Moro	+3	0	6	1	32.9	109	58.4	1
Itana 65	-1	0	2	3	32.7	108	61.4	1
Kharkof	0	0	1	3	29.6	100	60.8	14
Rio	+1	-1	1	3	28.8	98	60.6	14
Columbia	-3	-4	1	9	29.5	95	61.2	11

*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. 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 only two years of testing, it appears that Moro will be similar to Omar in most agronomic respects in the low rainfall area.

Nugaines

Nugaines is a sister selection to Gaines, developed by O. A. Vogel, ARS, Pullman. It has only been tested one year 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 two 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 and the prevalent dwarf bunt races in Washington. 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 Cheyenne in stripe rust resistance. Wanser is susceptible to foot rot and snow mold.

In yield tests over the last three years, Wanser has been equal to Burt and superior to Itana in yield. In 22 locations over the Pacific Northwest in 1964, Wanser was the highest yielding hard red variety with 47. 7 bushels; compared to McCall, 47. 1; Itana, 40. 7; and Turkey 38. 6. In 1965 Wanser yielded an average of 60.5 bushels, compared to McCall, 63.5; Itana, 52.7; and Turkey, 52.7. As shown in the preceding yield tables, Wanser is a consistently good yielder. 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. 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 as reported in the snow mold section. McCall has only fair mature plant resistance to stripe rust. It is slightly better than Burt, but inferior to Wanser. McCall has very good, quick emergence from deep seeding.

As shown in the preceding tables, McCall is a consistently high yielder, being equal or superior to Burt and better than Itana. The yield performance over the entire Pacific Northwest in 1964 and 65 was outstanding and is reported in the section on Wanser. McCall and Wanser were the two top yielding varieties in these tests and consistently ranked in the top 4 at all locations.

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 1957 - 65 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 7 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 7. Yield in bushels per acre and percent of Baart for spring wheat varieties at four locations in rod row plots.

Variety	Lind--15 yrs. Bu. acre	Lind--15 yrs. % Baart	H. Heaven--14 yrs. Bu. acre	H. Heaven--14 yrs. % Baart	Waterville--14 yrs. Bu. acre	Waterville--14 yrs. % Baart	Harrington--15 yrs. Bu. acre	Harrington--15 yrs. % Baart
Marfed	24.1	112	19.9	109	31.5	116	31.6	114
Lemhi	21.0	98	18.3	101	30.0	111	30.7	111
Federation	22.3	104	18.4	101	28.9	107	28.4	103
Idaed	21.3	99	18.5	102	27.3	101	30.4	110
Baart	21.5	100	18.2	100	27.1	100	27.6	100
Henry	18.6	86	17.4	96	23.8	88	28.7	104
Idaed x Burt -42-5*	26.6	110	15.2	102	30.9	113	30.0	110
Burt x Onas 52 -466**	26.4	111	13.3	104	29.5	111	29.1	113

* 4 years 1962 - 65

** 3 years 1963 - 65

The Dry Land Research Unit has over 150 crosses in various stages of development in the breeding program. Several crosses with excellent stripe rust resistance are in rod row trials this year. These include both red and white selections. Several selections from the Mexican breeding program have been yielding well, however the quality is not up to our standards. The breeding program is rapidly approaching the point where new material will be considered for state-wide testing.

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

G. W. Bruehl, Walt Nelson, and Orville Vogel

Snow mold is a serious problem on winter wheat in Douglas County and surrounding area where snow cover over long periods during the winter is common. A project to study this 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. The project leader is Dr. G. W. Bruehl, with breeding work done primarily by the Dry Land Research Unit and Agronomy Department.

In late summer, 1965, 5 wheat nurseries were seeded in a belt from west of Mansfield, Douglas County, to southeast Okanogan County. Varying degrees of snow mold attacked all 5 nurseries with speckled snow mold (Typhula idahoensis) prevalent in 4 and pink snow mold (Fusarium nivale) in the fifth. Snow mold was most severe at the Harold Beard and Dave Peterson ranches west of Mansfield. It was unusually uniform, making varietal comparisons reasonably accurate. The wheats that were most resistant in one nursery were most resistant in all the others, showing that snow mold resistance holds not only against the Typhula of the various ranches, but also against the pink snow mold. The agreement between the nurseries is encouraging as it indicates that wheats selected in one nursery will be equally resistant anywhere in the state.

This search for resistance began in earnest in the fall of 1960, and since that time at least 13,000 wheats have been tested in the field. This unwieldy number is now reduced to 15 wheats, either by straight winter kill or by susceptibility to snow mold. The 15 remaining wheats, including hard red, soft red and soft white wheats, can all be recommended to breeders as sources of useful levels of resistance to snow mold. This elimination of over 12,985 susceptible wheats from the testing program will free effort to be concentrated on progenies of crosses between resistant and commercial types. Thus the first phase, seeking and evaluating resistance, of the breeding problem is essentially completed.

Two of the most resistant wheats were selected by Dr. Don Sunderman at Tetonia, Idaho, and we are indebted to him for them.

The second phase of the program, determining whether resistance is an inherited characteristic, and whether enough resistance to be useful is transmitted in a cross, began in 1962. The first crosses were made at the Dryland Research Unit, Lind, in 1962, and at the Main Experiment Station, Pullman, in 1963. F_2's planted in fall of 1963 recovered from mold faster than the susceptible commercial parents, indicating the resistance was inherited. Some of the F_4 lines grown this year survived and recovered from the mold as well as the resistant parents of each cross, showing that worthwhile resistance is inherited. Therefore, development of resistant varieties through breeding is possible.

The third objective, development of a commercially acceptable, productive, adapted, usefully snow mold resistant wheat is the major objective before us. In some crosses at least, snow mold resistance is independent of head type and kernel color, so it should be possible to put resistance into common or club, white or red, soft or hard wheats. The wheat breeding program will include adding snow mold resistance to wheat varieties of each market class commonly grown in Washington. The most resistant wheats have weak, thin straw and developing varieties with adequate straw may slow us up. Preliminary milling and baking data on seed of resistant x susceptible wheats are encouraging. No predictions can be made as to when the first "resistant" wheat will be released, but the personnel at Lind and Pullman, Washington, and Dr. Donald Sunderman at Aberdeen, Idaho, are working toward this end. Some compromise on quality, yield, and other agronomic characters may be made in the first varieties released in order to speed up the first resistant variety, but breeding will continue to improve snow mold resistant wheats so that they are truly competitive.

Before closing this discussion, we should point out that McCall does not have enough resistance to snow molds to recommend it over other varieties on this basis. Likewise, Moro appeared superior to other commercial wheats last year. This year, in all 5 nurseries, Moro did not consistently resist the mold significantly more than Omar under heavy infection. Moro does possess the important feature of resistance to stripe rust, and in the snow mold country in early seedings this factor argues strongly for Moro.

It should be emphasized, too, that if snow fell early enough on unfrozen ground and lasted long enough, all wheats could be killed. Our experience indicates, however, that the resistance available will effectively protect wheat against all but extreme conditions. We have faithfully sought the worst mold spots for all our nurseries, and so far the 15 wheats have not been killed in nature in Washington (thirteen of them died under 8 feet of snow at Tetonia, Idaho, however).

Breeding resistant wheats would not be possible without the financial support of the Washington Wheat Commission. It would also be impossible without the cooperation of farmers in the heart of the worst snow mold areas. These farmers help us select spots where the mold is apt to be most severe and allow us to place our nurseries in these spots, regardless of how this may inconvenience them in their farming. In recent years Dave Petersen, Velmer Thomsen, Harold Beard, Richard Wainscott, Oliver Dezellum, and John Goldmark have cooperated in this way. We wish to thank the Wheat Commission and the farmers for their sustained support in this effort.

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, inoculated 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 indicates 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 foot rot infection.

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. Present varieties, except Moro, are susceptible in the seedling stage. Fall infection will continue to be a threat until all varieties have seedling resistance.

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 two years over 10,000 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 program for the low rainfall area.

Chemical control of stripe rust has not been very effective or economically feasible. A new chemical N-3412, has been very effective in the Willamette Valley. Although tested here, stripe rust infections have been too light to evaluate the chemical. This chemical is not available, and is not 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 resistance. 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 and varietal resistance breeding.[1]

---

[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.

WHEAT PRODUCTION MANAGEMENT

Wheat yields are very responsive to management practices in the low rainfall area. Where annual rainfall is 8 to 12", moisture conserving management is all important. Leggett (1) reported data over a wide range of moisture conditions in eastern Washington, and showed that every additional inch of moisture saved during either the fallow or crop year will increase the yield of winter wheat by 6 bushels per acre. Leggett and Nelson (2) reported that soil storage of rainfall in the fallow year varied with a range of 16 to 52% of the total rainfall. An average of about 35% of the rainfall was stored by the end of the fallow year.

The efficiency with which moisture is used by the wheat is an important factor in total production. Data show several factors are important in the overall efficiency of water usage. Factors which have been shown to influence moisture efficiency are date of seeding, variety, disease, and fertility level. Burt used 0.1 less inch of water for each bushel of wheat produced than Turkey over a 10 year period. Stripe rust disease decreased the efficiency by about 0.2 inch per bushel of wheat produced. Low fertility levels tend to decrease the total moisture used, but also decrease the efficiency with which the moisture is used.

Wheat is produced on from $\frac{1}{2}$ to $\frac{1}{4}$ as much total moisture in eastern Washington as in the Great Plains areas of Kansas, Nebraska, and Montana. This is important in management research. It means small gains in our moisture reserve are reflected in yield in this area more than in other wheat areas.

In 1965 the Washington Wheat Commission began supporting a project to study the "Factors affecting water conservation for plant growth in the low rainfall area of eastern Washington." Project leaders are Dr. F. E. Koehler, Dr. W. Gardner, and W. L. Nelson. The objectives and methods of the project are reported by Dr. Koehler.

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 allow the maximum probability of getting a good stand of wheat from an early seeding. Previous research results have shown that maximum efficiency of use of the limited moisture supply of this area can be obtained from an early seeding.

By use of supplemental water from a well currently being drilled with funds for general University improvement, the influence of different levels of soil moisture or moisture conservation can be studied.

Evaluation of soil moisture levels in the seeding zone will be made using radioactive techniques. These 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 block of soil 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. Then the block of soil will be dried in an oven and the density again determined. The change in density will be due to the loss of water. Therefore, soil moisture content and soil density can be 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 will be studied by other nuclear techniques. Aluminum tubes will be placed in the soil. A neutron soil moisture probe can be lowered into the aluminum tube and the moisture measured at any time and at any depth desired.

In addition to these studies, it is planned to study other factors affecting soil moisture levels in the seeding zone such as (1) depth of dry soil mulch on top, (2) soil temperature, and (3) tillage practices after a summer rainfall.

Recommendations for winter wheat production management based on data available for the 8 to 11" rainfall area are:

1. Summer fallow program of late fall chiseling of stubble, and an initial spring tillage to depth of 6" with sweep or offset disk. This should be followed immediately with sub-surface packing by skew treader, or disk running with little angle, or rotary hoe, or rod weeder. Rod weed as necessary for weed control. When cheatgrass is a problem, this method will have to be altered for additional cheatgrass tillage.

2. Fertilizer should be applied in summer fallow for winter wheat either in late spring or early summer or immediately before seeding. Nitrogen is the only fertilizer giving universal response. Sulphur and/or phosphorus may be needed where nitrogen alone does not respond. Soil tests in the top foot for phosphorus are recommended before any phosphorus is applied. Rates of 30 to 60 lbs. of nitrogen are recommended for this area.

3. Early deep seeding (Aug. 20 to Sept. 15) winter wheat of a recommended variety, is recommended. Use year-old seed whenever possible to eliminate high temperature dormancy of new seed. Seeding rates of 30 to 45 lbs. per acre are recommended for early seeding.

4. Seed late only if moisture is not adequate for early deep seeding. Late seeding is not a reliable weed control measure.

(1) Leggett, G. E. Relationships between Wheat Yield, Available Moisture and Available Nitrogen in Eastern Washington Dry Land Areas. Washington Agricultural Experiment Stations Bulletin 609, 1959.

(2) Leggett, G. E. and Nelson, W. L., Wheat Production as Influenced by Cropping Sequence and Nitrogen Fertilization in the 10- to 15- Inch Rainfall Area of Eastern Washington. Washington Experiment Stations Bulletin 608, 1959.

OIL CROPS

In cooperation with Dr. V. E. Youngman, WSU, the station has been testing oil crops during the last 10 years. Safflower and Crambe appear to have the most promise. Both crops are late maturing, and are poor competitors to Russian thistle. Both are better adapted to rainfall areas of more than 12 inches.

Safflower has a yield range of 400 to 800 lb. per acre in trials at the station. Weed competition reduced the yields by one third and made harvest very difficult. At prevailing prices it was not competitive with barley.

Crambe was grown in 1963. Yields were too low to compete with barley, and weed invasion made harvest very difficult. Crambe was seeded in 1964, but failed to emerge because of dry weather.

In 1965 good stands of both safflower and crambe were obtained. Temperatures of 23^{o} reduced the stands of crambe, but did not affect the safflower. Preplant treatment with Treflan at rates of $\frac{1}{2}$ and 1 lb. per acre followed immediately with a skew treader effectively reduced Russian thistle emergence without any visible damage to safflower or crambe.

In 1966 the Treflan treatments were repeated. The weather was extremely dry after seeding. The stands of both safflower and crambe were poor and very little emergence of Russian thistle occurred in the check. The Treflan appears to be effective again this year in the control of Russian thistle. The cost of the material is about $4 per acre for adequate weed control.

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, and 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 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 crab apple 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 8. 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.