FIELD DAY

Dry Land Research Unit

Lind, Washington

June 29, 1972

INTRODUCTION

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

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

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

In 1947 the station was named the Dry Land Experiment Station. This name was changed again in 1965 to the Dry Land Research Unit. Although the name has changed, the station still is devoted to dry land research. This experiment station has the lowest rainfall of any research station devoted to dry land research in the United States.

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

The major portion of the research has centered around wheat. Variety adaption, wheat production management including weed and disease control, and wheat breeding are the major programs of research in recent years. Although many varieties of wheat have been recommended from variety trials by the station, Wanser and McCall were the first varieties developed on the station by plant breeding.

Since 1916 an annual field day has been held to show farmers and interested businessmen the research on the station. This year marks the 55th field day. Visitors are welcome at any time. Their suggestions are appreciated.

COMMENTS AT LIND FIELD DAY

James Nielson

Last winter we conducted a rather thorough review of our entire wheat research program in light of our budget situation and in relation to decisions being made by the Agricultural Research Service, USDA. The review included the work at Lind, especially in light of Walt Nelson's having resigned last October.

It has been and will continue to be the objective of the WSU Agricultural Research Center to produce research results that fit as many of the growing conditions in the state as our resources will permit. The Dry Land Research Unit is representative of a significant part of the total dry land wheat areas of Washington, and is well adapted to wheat research on breeding, diseases and pests, soil moisture, and production management. Not surprisingly then, we decided to move forward with plans to continue research on wheat (and other cereal grains) at this Unit.

We are fortunate in being able to retain Dr. Ed Donaldson, with an excellent background in wheat breeding research, as project leader at Lind (and we appreciate the continuing contributions of Dick Nagamitsu). Ed began work at the Unit on April 1, and reports directly to the Chairman of the Department of Agronomy and Soils, Jim Engibous. We believe this administrative arrangement provides the best system for coordinating the entire wheat research program and for communicating activities to the growers. Scientists from our Department of Plant Pathology as well as Agronomy and Soils at Pullman are involved in the research program at Lind. ARS scientists stationed at Pullman are also deeply involved in the research. The Lind Unit provides a unique facility to be used by all WSU and ARS scientists conducting wheat research.

Wheat breeding and selection will continue to be a major emphasis in the research program at Lind. One of the objectives of the breeding work will be to develop wheat varieties adapted to low rainfall conditions. Considerable attention will be given to hard red winter wheats and to the development of cold resistant and drouth resistant spring wheats adapted to low rainfall areas. The spring wheat program is an integral part of the total spring wheat effort coordinated out of Pullman, and as such exemplifies the close ties and cooperation of the two locations. Some work may also be conducted on white winter wheats. Developing resistance to diseases--especially snow mold, stripe rust, and foot rot--will be an important part of the research program. Research will continue on soil moisture, tillage methods, and other production practices. This type of work will be coordinated closely with USDA programs at the Pendleton station.

We are pleased with the financial and other support the Washington wheat industry has provided, not only for our work at Lind, but for our entire wheat research program. Given our budget situation, we will need your continued support. In fact, with expanded support we could push ahead more rapidly on research on urgent problems facing the state's wheat industry.

CLIMATIC DATA

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

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

Month	Temperature °F. Max.	Temperature °F. Min.	Precipitation 1971	Precipitation 1972	Precipitation 51 yr. av. (in)
January	34	22	.89	.37	1.05
February	42	24	.33	.42	.90
March	53	32	1.44	1.00	.72
April	63	35	.71	.47	.64
May	72	42	1.06	1.02 (May 25)	.76
June	83	45	.89		.93
July	90	52	.34		.21
August	90	50	.22		.31
September	79	45	.85		.54
October	65	38	.51		.91
November	47	29	.87		1.21
December	37	26	1.25		1.25
			9.36		9.43

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

RESEARCH OF CEREAL CROPS

The object of the Dry Land Research Unit's cereal breeding and testing program is to provide adapted cereal varieties 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 mid-west and Pacific Northwest and foreign breeding programs. Within the total wheat breeding program in Washington State, the Dry Land Research Unit has primary responsibility for the breeding and development of hard red winter wheats, and cooperates in the breeding and development of spring wheats. Virtually all of the breeding and development of white winter wheats is carried out by USDA personnel at Pullman, with the Dry Land Research Unit cooperating in yield testing.

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

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

WHEAT BREEDING

Winter Wheat Breeding At The Dry Land Research Unit

E. Donaldson and 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 capable of producing high quality hard red wheat, which includes most of the area having less than 10 inches of annual rainfall.

The program was started in 1951 with parent evaluation. Since 1952 crosses have been made each year to continually add new germ plasm for yield, quality, winter hardiness and disease resistance. Many crosses have been between high yielding white wheat varieties and the better yielding hard red varieties to improve the yield potential of adapted hard reds. Disease resistance is of major concern in the program and includes crosses for stripe rust, smut, foot rot, and snow mold resistance.

Stripe rust screening of breeding material and advanced lines is possible during the winter months in the greenhouse section built with Wheat Commission funds. As a result susceptible lines can be eliminated earlier in the breeding program, allowing more emphasis to be placed on the highly resistant lines, and, thus, greater progress for stripe rust resistance.

Snow mold resistance has been included in the program since 1963. Over 100 crosses with 10 sources of snow mold resistance have been made. Second generation crosses on the most promising snow mold lines are now nearing the yield testing stages.

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 yields of recommended varieties for low and intermediate rainfall areas of Washington and Oregon are given in Table 2. In Tables 3, 4, and 5 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 6 gives the data from large scale field plots at Lind. Data from these trials and other large scale field plots in eastern Washington are used to make variety recommendations. Variety recommendations for the different rainfall areas are included in this brochure in the section by Dr. Morrison.

Table 2. Yield of selected varieties in low and intermediate rainfall areas in Washington and Oregon, 1964-71.

Variety	Lind 9.5"	Moro, Ore.* 11"	Pomeroy 14"	Pendleton 14"	Average
	Location and Rainfall				
Nugaines	41.8	34.1	67.7	72.2	54.0
Luke**	40.7	43.4	60.0	79.0	55.8
Burt	37.9	34.5	53.3	61.5	46.8
Coulee**	36.9	33.8	56.3	69.9	49.2
Moro	39.7	33.4	59.1	59.2	47.9
Paha**	40.5	33.0	58.2	71.7	50.9
Wanser	38.8	33.9	55.0	64.8	48.1
McCall	39.2	34.5	55.6	64.5	48.5
Cheyenne	37.6	32.7	53.6	57.0	45.2
Kharkof	34.5	28.2	50.2	51.9	41.2
Station Av.	38.8	34.1	57.6	65.0	48.9

*Moro location 7 years - 1965 missing
**4 yr data, except Luke, 2 yr at Moro and Pendleton

Table 3. Summary of agronomic characteristics of winter wheat grown at Lind in rod row nurseries, 1952-71

Variety	Av. plant ht.	Av. test wt.	1971 yield bu/a	Av. yield bu/a	Yield % Kharkof	No. years grown
Nugaines	25	62.4	44.1	41.8	123	7
Luke	25	61.1	46.6	40.7	126	4
PI181268/Gaines S. 399-6	25	63.0	36.6	36.6	114	1
Moro	29	59.3	45.1	39.7	115	8
Paha	27	60.7	44.0	43.9	133	5
Burt	29	61.2	37.8	36.4	116	17
Coulee	24	62.4	36.8	36.9	114	4
Wanser	30	62.5	38.1	38.8	112	8
McCall	30	62.7	40.3	51.7	114	8
Cheyenne	32	61.8	35.6	37.2	113	14
Kharkof	32	60.7	32.1	31.3	100	17

Table 4. Summary of agronomic characteristics of winter wheat varieties grown near Waterville in rod row nurseries, 1952-71.

Variety	Av. plant ht.	Av. test wt.	1971 yield bu/a	Av. yield bu/a	Yield % Kharkof	No. years grown
Nugaines	26	63.3	44.5	50.1	138	5
Luke	26	62.7	48.2	43.5	158	2
PI181268/Gaines S. 399-6	30	63.0	45.9	45.9	140	1
Moro	33	60.4	44.4	44.8	124	5
Paha	27	61.9	45.1	42.4	135	3
Burt	31	61.7	40.0	40.2	119	14
Coulee	24	63.5	36.4	35.6	113	3
Wanser	34	63.0	37.3	43.9	122	6
McCall	33	63.1	40.3	43.7	121	5
Cheyenne	37	62.2	35.3	40.3	114	11
Kharkof	38	61.8	32.9	33.7	100	15

Table 5. Yield in bushels per acre and per cent of Kharkof for winter wheat varieties at two locations in rod row plots.

	HARRINGTON 1952-71			HORSE HEAVEN 1951-71		
Variety	No. years grown	% Kharkof	Av. yield bu/a	No. years grown	% Kharkof	Av. yield bu/a
Nugaines	6	159	44.5	2	136	23.8
Luke	3	179	43.7	2	126	22.1
PI181268/Gaines S. 399-6	1	143	45.2	-	---	----
Moro	6	146	41.0	4	119	18.0
Paha	4	188	46.8	2	121	21.3
Burt	18	127	44.6	11	117	21.3
Coulee	4	145	39.0	2	125	22.0
Wanser	5	148	39.6	5	123	19.8
McCall	5	157	42.0	5	121	19.6
Cheyenne	-	---	----	10	115	20.2
Kharkof	18	100	35.2	12	100	18.2

Table 6. Summary of agronomic data for winter wheat variations grown at the Dry Land Research Unit in drill strip plots, 1954-71.

Variety	Av. date head	Av. plant ht.	1971 yield bu/a	Av. yield bu/a	Yield % Kharkof	Av. test wt.	No. years grown
Nugaines	5/31	25	42.1	39.4	121	61.5	6
Luke	6/5	25	41.4	44.6	117	60.3	2
Moro	5/30	30	46.5	41.6	128	58.7	6
Paha	6/5	27	46.2	50.4	132	60.8	2
Burt	5/29	29	41.1	36.4	114	61.0	16
Coulee	6/1	25	37.6	41.1	107	61.6	2
Wanser	5/28	30	40.7	38.3	115	62.0	8
McCall	5/30	29	41.5	38.4	117	62.0	7
Kharkof	5/30	33	37.4	31.8	100	60.6	16

Spring Wheat

The spring wheat breeding program at the Dry Land Research Unit is a cooperative effort with the spring wheat breeding program at Pullman. This approach provides a wider climatic base for selection and early generation testing and should yield selections adapted to a wider range of enrivonments. Both red and white spring wheats are included in this program.

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

Tables 7 and 8 show the agronomic characteristics of standard spring wheat varieties grown in the dryland region.

Marfed has the highest long time yield average at all locations.

Henry/Burt, Selection 65-2 is a standard height hard red spring wheat with acceptable quality, but is susceptible to stripe rust. Era Sib 2 is a semi-dwarf hard red spring wheat, with acceptable quality and fair stripe rust resistance. It is not well adapted to areas with less than 10 inches of annual rainfall, but has a higher yield potential, and is less subject to lodging than Henry/Burt, Selection 65-2 when grown under irrigated or supplemental irrigated conditions. CI13448/Marfed, Selection 68-3 is the most promising soft white spring wheat selection.

Table 7. Summary of agronomic characteristics of spring wheat grown at Lind in rod row nurseries, 1950-71.

Variety	Av. date head	Av. plant ht.	1971 yield bu/a	Av. yield bu/a	Yield % Baart	Av. test wt.	No. years grown
Marfed	6/15	26	30.7	24.1	114	58.8	21
Twin	6/14	22	31.7	24.7	120	57.3	4
Idaed (Idaed 59)	6/9	25	21.8	20.9	98	59.1	21
Baart	6/11	28	24.6	21.3	100	60.2	21
CI13448/Marfed S. 68-3	6/20	24	29.9	26.1	114	59.9	2
Adams	6/13	26	*	23.0	108	59.3	7
Burt/KF 58-2025	6/15	25	25.0	24.0	107	58.1	8
Henry	6/11	27	*	20.0	94	59.1	16
Henry/Burt S. 65-2	6/17	28	27.2	25.9	113	59.4	2
Era Sib 2	6/15	22	28.2	22.5	104	60.1	3

*Not grown

Table 8. Yield in bushels per acre and per cent of Baart for spring wheat varieties at three locations in rod row plots.

	Harrington			Waterville			Horse Heaven		
Variety	No. years grown	% Baart	Av. yield bu/a	No. years grown	% Baart	Av. yield bu/a	No. years grown	% Baart	Av. yield bu/a
Marfed	21	117	31.0	20	114	30.2	18	109	18.9
Twin	3	106	31.0	3	109	29.6	3	98	13.1
Idaed (Idaed 59)	20	114	29.6	19	102	26.8	17	100	16.9
Baart	21	100	26.5	20	100	26.5	18	100	17.4
CI13448/Marfed S. 68-3	2	107	30.8	*	*	*	1	106	26.7
Adams	6	107	27.6	6	107	26.9	5	99	13.4
Burt/KF 58-2025	7	105	25.8	7	102	26.4	6	92	11.0
Henry	17	106	28.2	16	96	25.9	15	96	17.5
Henry/Burt S. 65-2	2	106	30.5	2	92	27.0	2	95	15.0
Era Sib 2	1	99	35.8	1	98	29.3	2	97	16.3

*Not grown

WHEAT DISEASES

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

Stripe Rust

J. Walter Hendrix

Stripe rust, based on surveys made as late as the middle of May, appears to be at the lowest level in Washington since 1959. In spite of some early planting in the southcentral part of the state, very little fall infection took place. The sparse fall infection, together with normal winter attrition, is reflected in a virtually rust-free spring situation. My prediction is that there will be no measurable loss on a state-wide basis.

While it is not possible to identify all of the factors responsible for the decline of stripe rust, the continued use of varieties carrying genes for resistance has undoubtedly played a part. Undoubtedly the low level of inoculum carry over from the 1971 crop, combined with currently used cultural practices as well as prevailing weather conditions, has also contributed. Irrespective of the reasons, we can be thankful for a lull in the attack by this otherwise destructive disease.

In greenhouse tests at Pullman where severe rust can be imposed on plants, 40 of the most promising and advanced selections from the Allan, Bruehl, Konzak, Pope, and Peterson-Vogel breeding programs were tested. These annual tests are designed to keep abreast of new breeding developments, to test all new lines of wheat under exactly the same environmental conditions, and to avoid the chance factor associated with field testing. While a number of lines were too susceptible to justify release, there is no doubt but that great strides have been made in recent years. Older susceptible checks like Omar and Orin still suffer losses approximating 75% while the better new selections are reduced less than 20%. A few lines suffered less than 5%.

Snow Mold

G. W. Bruehl, Dick Nagamitsu, C. J. Peterson, and E. Donaldson

Snow mold was destructive in parts of Douglas County for the fourth consecutive year--a record so far as we know--but we hope relief is in sight. A common white soft wheat, PI181268/Gaines, Selection 399-6, is being increased and is under consideration for release.

Selection 399-6 has survived severe mold to recover strongly in 1971 and in 1972. It has weak straw, medium yield potential, is resistant to stripe rust and common bunt but is susceptible to dwarf bunt. It does well only from early seeding and is adapted only to western Douglas and to Okanogan Counties. If released, it should be looked upon as a special situation wheat suitable for use only in a limited portion of Washington. Its milling and quality characteristics are similar to Nugaines.

With luck, significant quantities of seed of Sel. 399-6 could be available for the fall of 1973.

Luke and Moro have resistance adequate for light to moderate attacks, but will not survive severe snow mold.

The severe test in our nursery insures real progress in wheat selection this year. Wheats of all the breeding projects were in the trial (clubs, soft white, and hard reds), so hopefully better wheats with good resistance will follow 399-6 before too long. Development of resistant varieties should become easier as resistance is moved into better agronomic types.

Dr. Sunderman, USDA wheat breeder at Aberdeen, Idaho, had five hard red selections in our test and they all had good resistance. We do not know their agronomic characteristics, however.

Cercosporella Foot Rot

G. W. Bruehl, C. J. Peterson, and O. A. Vogel

The moist late spring of 1971-1972 made *Cercosporella* straw breaker more important in more of the dry land area last year than we have ever seen before. How frequent significant losses will occur on extensive acreages in this region is not known, and at present research on this disease is concentrated in more humid areas.

Luke is the most resistant of present commercial wheats and can be grown in most of the problem areas. A single application of a fungicide may provide economical control in early-seeded wheat in real problem areas. It is under trial primarily in Columbia, Whitman, and Spokane Counties.

Root and Foot Rots of Wheat

R. James Cook

Tests were conducted in 1970-71 near Harrington, Washington, in a field highly infested with *Fusarium roseum* f. sp. *cerealis* 'Culmorum' to determine varietal resistance and to study the relationship of host genotype, nitrogen rate, and plant density to soil water use, plant water stress, and severity of *Fusarium* foot rot. There was no shortage of soil water at the plot site in that late spring rains virtually kept pace with water use by the wheat well into June. In the past, a wet year has meant a "lost year" from the standpoint of *Fusarium* foot rot experiments, because the disease relates to water stress. This year was an exception, in that severe disease developed in some varieties and in response to some nitrogen treatments, even though water in the soil profile was ample for a healthy crop. For the first time, we were able to "turn on" the *Fusarium* in a wet year. We now have a more dependable test method for use in varietal testing, and we obtained new clues to the nature of plant water stress with nitrogen fertilizer that may eventually bear on improved cultural practices for disease control.

Treatments that promoted most severe foot rot were those with high rates of nitrogen fertilizer. The highest rate used was 120 lbs/A which, in a 12 to 14 inch rainfall area is well above the recommended rate. The result was greater plant water stress during the growing season (as monitored by thermocouple psychrometer measurements of leaf water potential), and severe onset of disease toward the end of the season. In contrast, plots of low fertility were slow to stress and disease remained low. An intermediate rate of nitrogen (60 lbs/A) also favored the disease, but generally less than the high rate. Widening the rows from 12 to 24 and 36 inches offset the influence of high nitrogen to some extent, and reduced disease at the 120 pound nitrogen rate. The greater disease severity with narrow rows, high nitrogen, or both, possibly removed the yield advantage one would expect from these treatments in a wet year which may be reflected in the yield data in the table below.

Table 9. Bushels/A of Nugaines wheat in 1971 *Fusarium* trial, Harrington row spacing (inches apart).

lbs N/A	12	24	36
0	44.2	43.5	42.8
60	55.5	55.8	49.0
120	55.9	54.8	48.5

Each value is the average for 4 reps

For the third year in *Fusarium* trials, Luke displayed considerable resistance to *Fusarium* foot rot. Incidence of severe disease in this variety was approximately 1/3 that in Nugaines with 60 lbs N/A. Overall yields in a three-rep plot were 69.3 and 59.5 for Luke and Nugaines, respectively. Coulee, on the other hand, showed twice the incidence of disease compared to Nugaines, and averaged 47.6 bu/A in the trial. Coulee fit the general pattern of hard wheats being particularly sensitive to conditions which lead to soil and plant water stress, to *Fusarium* foot rot, or a combination of the two. The three club wheats in the test, Moro, Omar and Paha, all showed the least evidence of water stress (as indicated by leaf water potentials through the growing season), showed the same amount of foot rot as Luke, and yielded about the same as Nugaines. This fits the general pattern of certain club wheats being tolerant to conditions that lead to soil or plant water stress, *Fusarium* foot rot, or both.

One immediate return of this work concerns the proof we now have for the influence of high nitrogen on foot rot. This provides an additional tool in testing programs. It also emphasizes the importance of applying no more N than suggested through the fertilizer testing service. The 120 lb/A rate we used is not unusual in some fields where 50 or 60 lbs are applied on top of 60 or 70 lbs residual from the previous crop. The presence of *Fusarium* in a field narrows the degree of margin by which a grower can exceed optimum nitrogen rates and still expect maximum yield.

Soils from fields with long-term wheat culture were confirmed to be antagonistic to the wheat root parasite, Ophiobolus graminis. In contrast, virgin, nonagricultural soils exhibit little or no antagonism to O. graminis, even when collected from sites adjacent to cultivated, antagonistic soil. Fumigation with methyl bromide of soil in field plots in the greenhouse eliminated the antagonistic factor which could then be reestablished in the fumigated soil by amendment with 1% antagonistic soil. A 1% or 10% amendment with virgin soil gave little or no reestablishment of antagonism. Steam pasteurization at temperatures as low as 140°F eliminated the antagonism from each of three markedly different long-term wheat field soils. This clearly indicates that the responsible factor is biological, and that it may hold potential in biological control, if transferred to nonantagonistic soils. Sensitivity to low heat rules out spore-forming bacteria as responsible for the antagonism.

WHEAT, OATS, BARLEY

Kenneth J. Morrison

Winter Wheat

Paha

Paha is a short, standard height, Omar-type white club wheat selection made at Pullman, Washington. The selection is shorter but in other characteristics is similar to Omar in appearance and in reaction to common and dwarf bunt. The high resistance to stripe rust was inherited from Suwon 92. It has moderate resistance to Cercosporella foot rot. The variety is superior to Omar in resistance to lodging, shattering, but is notably more susceptible to powdery mildew and flag smut. Good germination and emergence characteristics of the selection are similar to Omar.

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

The high susceptibility of Paha to dwarf and flag smut are expected to retard its widespread adoption in the intermediate rainfall area. This selection would fill the need for a low protein, high quality Omar-type club wheat highly desired in the domestic and Japanese market. Seed for commercial wheat production will be available for seeding in 1971.

Moro

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

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

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

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

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

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

Selection 399-6

Selection 399-6 is a soft white common wheat being considered for release. The chaff varies from white to gray-brown; the heads are small and awnletted. The variety is 3 to 6 inches shorter than Wanser and McCall, and about 3 inches taller than Luke. The variety heads about the same time as Wanser and McCall. It has high tillering capacity from early seedings, but the straw is weaker than Luke. The test weight of Selection 399-6 is below Nugaines but it has been above 60 pounds per bushel.

Selection 399-6 has good resistance to snow mold, stripe rust, and common bunt, but is susceptible to dwarf bunt and Cercosporella foot rot. Reaction to flag smut is not known.

It has excellent emergence and adequate winter hardiness.

The selection has survived in all snow mold trials in Washington. In the most severe test site in Douglas County in 1971, no commercial control was harvested, while Selection 399-6 yielded 70 bushels per acre. Tests indicate that 399-6 has sufficient yield to compete in severe snow mold regions in Washington. Its inferior plant type should preclude its use in other areas. The variety should be grown in areas where snow mold is a major problem. Because of its weak straw and lower yield, it should not be grown in more productive areas where snow mold is not a problem. The original crosses were made by Dick Nagamitsu and Walt Nelson at the Dry Land Research Unit at Lind in 1962. Final selection was made in 1968 by Dr. Nelson, Mr. Nagamitsu, and Dr. Bruehl, Washington State University. The selection will be named Sprague when released.

Coulee

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

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

Burt

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

Luke

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

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

Nugaines

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

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

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

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

Wanser and McCall

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

The two varieties can be distinguished by chaff color. Wanser has a brown-chaffed head; McCall a white-chaffed head. Both have bearded, common-type heads and medium height straw that resists lodging. Both varieties are resistant to common smut and most races of dwarf bunt. Wanser is highly resistant to flag smut.

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

McCall is well adapted to the northern section of the Big Bend area including Douglas, Grant, and Lincoln Counties. McCall is superior to Wanser in both snow mold tolerance and emergence from deep seedlings--two qualities important to production in this area. McCall recovers rapidly in the spring which is another advantage for the northern area.

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

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

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

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

Spring Wheat

Marfed

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

Idaed-59

Idaed-59 is a common soft white wheat that is very similar in appearance and growth habits to Idaed. It matures early and has short, medium stiff straw. Idaed-59 has a beardless, white-chaffed head. It has fair field resistance to stripe rust and is resistant to the stem rust common in Eastern Washington. It resists shattering. In late seedings, Idaed-59 matures from 7 to

10 days earlier than other spring wheat varieties. In the higher rainfall areas, it is well suited to late seedings on heavy soils and early seedings on shallow soils. Like Idaed, some dry area seedings may not be uniform in height at harvest time, making harvest difficult. Idaed-59 is recommended for spring seeding in the 12-inch and higher rainfall areas and for late seedings on irrigated land in Central Washington.

Baart

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

Henry

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

Twin

Twin is a soft white spring wheat named and released by Washington, Idaho, and Oregon agricultural experiment stations and the Crops Research Division, U.S. Department of Agriculture. Twin has a higher yield record under dryland conditions than Marfed. Twin did better under irrigation at Ellensburg but did not do as well as Marfed at Othello. Twin has a lower test weight than Marfed, it has shorter straw, and is more lodging resistant.The variety is resistant to prevalent races of stripe rust but is susceptible to leaf rust and mildew. Twin is an awnless wheat of medium maturity, has white chaff and moderately stiff straw. The variety was developed at the Idaho Branch Experiment Station at Aberdeen, Idaho.

Durum--Wandell

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

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

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

Spring Barley

Steptoe

Steptoe is a six-row spring feed barley with a higher yielding record than Unitan or Gem. The test weight is higher than Gem and about equal to Unitan. Steptoe heads about the same time as Unitan and about five days later than Gem. The variety has stiff straw with better lodging resistance than either Gem or Unitan. The straw is about the same height as Gem, but 3 to 4 inches shorter than Unitan. The heads are erect with rough awns, the seed and the kernels are the same size as Gem, but slightly larger than Unitan. Steptoe is recommended to replace Gem and Unitan. Steptoe has a higher yield record at most locations.

The variety was developed by Dr. Robert Nilan and Mr. Carl Muir, Washington State University plant breeders. The selection was made from an experimental selection crossed with Unitan.

Gem

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

Unitan

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

Piroline

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

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

Traill

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

Vanguard

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

Belford

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

Winter Barley

White Winter

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

It is not recommended for spring planting.

Luther

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

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

Kamiak

Kamiak is a winter barley similar to Hudson in appearance. The selection has been tested at Pullman, Pomeroy, and Dayton, where it has produced higher average yields than Hudson. It is about equal to Luther in most locations. Kamiak is equal to Hudson in winter hardiness with slightly larger kernel size than either Hudson or Luther. It is more lodging resistant than Hudson with shorter straw, but it is slightly taller than Luther. The test weight of Kamiak is higher than Luther, but slightly lower than Hudson. The variety matures about the same as Hudson, but is at least 10 days earlier than Luther. Kamiak does not have small, glume hairs which cause "itching" during the threshing of Luther.

Kamiak should perform well in Eastern Washington where Hudson is being grown.

Oats

Cayuse

Cayuse is a high yielding, moderately early spring oat recommended in Washington and Northern Idaho. It is a short, pale green variety with open and spreading heads. The straw is strong and resistant to lodging. The kernels are light yellow.

Cayuse has yielded 10 to 20 per cent more than Park in test plantings.

The main weakness of Cayuse is its test weight, which is relatively lower than that of Park. The test weight of Cayuse has averaged about 35 pounds per bushel in all Washington locations compared with 37 for Park.

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

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

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

Park

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

RECOMMENDED VARIETIES - WHEAT, OATS, BARLEY

EASTERN WASHINGTON	WINTER WHEAT	SPRING WHEAT	OATS	SPRING BARLEY	WINTER BARLEY
14 inches or more rainfall	Nugaines Luke Paha	Marfed Idaed-59 Twin	Cayuse Park	Steptoe Gem Unitan Traill--malting barley Belford--for hay only Piroline--malting barley Vanguard	White Winter--18 inches or more rainfall Luther Kamiak
EASTERN WASHINGTON					
Less than 14 inches rainfall	Wanser McCall Moro Burt Paha Nugaines Coulee	Baart--8-12 inches rainfall Henry--for reseeding in hard red winter Marfed--10 inches or more rainfall Idaed-59--12 inches or more rainfall		Unitan	
CENTRAL WASHINGTON					
Under irrigation	Nugaines	Marfed Idaed-59 Wandell (Durum)	Cayuse Park	Gem Belford--for hay only	Luther
Douglas County (snow mold area)	Selection 399-6				

WEED CONTROL IN WINTER WHEAT

Dean G. Swan

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

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

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

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

Experiments with these herbicides have been conducted for several years at many locations. Results from these experiments show that growers, by choosing the right selective herbicide and with appropriate timing, can control virtually all problem broadleaf weeds in the winter wheat-producing areas in Eastern Washington.

NOTE

These herbicides should not be applied when the wheat is under stress from winter injury, heaving, frost damage, drought, etc. Selectivity is decreased and crop damage might occur.

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

TILLAGE PRACTICES

Tillage Practices For Dry Land Wheat Production

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

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

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

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

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

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

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

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

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

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

1. After harvest, sweeping where weed infestation occurs.

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

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

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

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

6. Deep furrow seeding of recommended variety starting approximately August 20 in Douglas County, September 1, in areas similar to Lind, and September 10, in 11 to 12 inches rainfall areas of Lincoln County. It is better to have a stand of wheat seeded 10 days too early, than a poor stand of wheat seeded at the optimum time or seeded late.

7. Seeding rate for early seeding should not exceed 45 pounds per acre, and 30 pounds is enough for early seeding that germinates well.

Tillage Practices for Moisture Conservation and Early Stand Establishment

F. E. Koehler and Mike Lindstrom

Information reported in this section of the field day brochure has been made possible by Washington Wheat Commission's support of project 1857 entitled "Factors affecting water conservation for plant growth in the low rainfall area of Eastern Washington."

The purpose of this project is to determine which soil structural and physical condition as influenced by tillage will provide the maximum moisture for the wheat crop with special emphasis on the moisture in the seed zone. This would increase the probability of getting a good stand of wheat from an early seeding. Previous research has shown that maximum efficiency of use of the limited moisture supply of this area can be obtained from an early seeding.

Fall tillage treatments studies have been: (1) disc at 5-6 inches deep, (2) chisel at 9-10 inches deep with chisel points on 12 inch centers, and (3) no fall tillage. Spring tillage treatments studies have been: (1) disc at 5-6 inches deep, and (2) sweep at 5 inches deep with 18 inch shovels in 12 inch centers, and (3) sweep at 8 inches deep. The three spring tillage treatments were applied to each fall treatment giving a total of nine different tillage treatments. All tillage treatments were then gone over with a skew treader to firm up the soil and then rod weeded. Plots have also been set out to determine the effects of tillage on moisture conservation. Weeds were controlled in these plots by chemicals. Additional studies had been included to study the effects of time of initial spring tillage and surface on total soil profile water content and seed zone water.

Fall and Spring Tillage Study

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

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

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

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

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

Time of Spring Tillage Study

Time of spring tillage plots was established to study the effect of the date of initial spring tillage on fall chiseled and fall non-tilled plots. Dates of spring tillage were: early--as soon as equipment could be used in the field (mid to late February); normal--late March or early April; late--May 1; and very late--June 1. Weeds were controlled with chemical and all plots were kept free of weeds, regardless of time of initial tillage.

During the two previous years of this study, spring rainfall did not contribute to total soil water. In fact, total soil water in the profile decreased during this period. Results from this study last year show only a slight loss for the period from the early spring tillage treatment to the late spring treatment, and then an increase in total soil moisture for the very late tillage treatment was observed. The loss in total moisture during the early portion of this study was not as great as it had been in previous years. Rainfall last spring was higher than average which reduced water loss during the early portion of the experiment and then a sizable rain (0.61 inch) just prior to the very late spring tillage increased the total soil water content for this treatment over the normal and late spring tillage treatments.

Normal rainfall at Lind during the period between the early and very late tillage treatment is approximately 2.5 inches. Rainfall during the two previous years of this study were quite close to the average and total soil water, seed zone moisture, and rate of emergence decreased as time of initial spring tillage was delayed. Rainfall during the past study was 3.8 inches, which indicates that total soil moisture can be maintained during the spring season if rainfall is adequate. But it was observed that even with the higher than normal rainfall, the early initial spring tillage date was equal to the best of the later treatments.

Time of Secondary Tillage Study

Plots have been established to determine the effect of time of secondary tillage on seed zone moisture. Initial spring tillage was performed with a sweep plow. Secondary spring tillage was with a skew treader at weekly intervals after initial spring tillage. To date, nothing conclusive has been determined.

Surface Structure Plots

Plots were established to determine the effect of surface structure on seed zone moisture. It has been observed that clods on the soil surface do not lower seed zone moisture, but if the clods become too large and are distributed throughout the dust mulch layer, then a reduction in seed zone moisture occurs.

Temperature and Moisture Effects on Rate of Emergence

Field plots were established to determine the influence of soil temperature and moisture on the rate of emergence this past summer. Observations indicate that temperature has a major influence on emergence rate, whereas, moisture did not influence emergence rate to any great extent until the moisture level dropped below 9 per cent (water potential of - 2.5 bars). As the soil temperature in the seed zone increased, the rate of emergence increased. For example, at a mean temperature of 57°F it took 8 days for Wanser to emerge from a depth of seeding of $2\frac{1}{2}$ inches, while it only took 5 days to emerge from a depth of 5 inches when the mean temperature was 75°F.

Additional work has been conducted in the lab under controlled conditions. Essentially the same effect has been noted as was observed in the field. That is, temperature has a major effect on rate of emergence while moisture does not influence the rate of emergence until the water potential drops below - 2.5 bars. Emergence does occur in the lab down to - 11 bars (6 per cent water in Lind soil), but rate is very slow.

MANAGEMENT PRACTICES FOR WHEAT PRODUCTION UNDER SUPPLEMENTAL IRRIGATION

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This project, designed to find the best soil fertility and other cultural practices necessary for wheat production to utilize limited irrigation water most effectively, is being supported by the wheat industry through the Hay and Grain Fund. Data has been obtained from experiments in 1968, 1969 and 1970, at the Lind Station.

Irrigation treatments were:

1. one 4 inch irrigation in early April
2. one 4 inch irrigation in early May
3. two 4 inch irrigations as in 1 and 2 above
4. same as 3 plus 4 inch irrigation in early June.

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

The yields, protein concentrations, and 1970 test weights are given in Table 10.

In 1968, 1969, and 1970, sixty pounds of N per acre gave near maximum yields where only one irrigation was used. With two or three irrigations, maximum yields occurred at about 120 lbs. N per acre. In 1968 and 1969, yields were severely reduced by unfavorable weather conditions. In 1968, the crop was damaged by a severe frost which occurred in late April. In 1969, stands were reduced by winter kill and the remaining plants were injured by the extremely low late December temperatures. For the 1968 crop, protein content increased with increasing rates of nitrogen application, but did not reach objectionable levels until maximum yields were obtained.

In 1970, yields were substantially higher. Due to extremely high NO_3-N levels prior to seeding, 60 lbs. N per acre gave near maximum yields in every case. The higher rates of nitrogen resulted in excessive vegetative growth and water stress, thereby reducing the yield. Table 10 shows the ability of the June water to restore yields above the April-May water treatment, at high nitrogen rates. The magnitude of the response was probably enhanced by the hot June weather.

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

A dryland wheat yield of 50 bushels was assumed to calculate Table 11. The yield over 50 bushels was divided by the water applied to give the response per inch of water added.

Table 10. Yield, protein concentration and 1970 test weights of Nugaines wheat grown with different levels of N fertilization and supplemental water application. Lind, 1968, 1969, and 1970

Rate of N lbs/a	April				May				April - May				April, May & June			
	1968	1969	1970	1971	1968	1969	1970	1971	1968	1969	1970	1971	1968	1969	1970	1971
									Bu/a							
0	35	26	75	67	33	34	78	67	31	26	89	68	35	31	104	72
60	46	31	73	79	46	41	83	73	58	53	97	98	59	53	110	103
120	51	32	60	78	48	44	78	79	68	59	83	102	71	63	113	109
180	48	39	62	78	43	43	77	76	65	60	79	105	68	64	102	108
240	49	45	59	74	45	36	75	79	64	53	67	95	72	66	99	120
300	44	45	62	74	46	42	73	81	63	60	69	100	76	71	97	109
									% Protein							
0	6.4	12.2	8.3	7.6	6.9	11.8	8.1	8.0	6.6	11.3	7.8	5.9	6.9	10.8	7.5	6.3
60	8.8	12.2	10.3	9.0	8.0	12.2	9.5	8.5	7.3	12.2	9.2	7.3	7.8	11.5	7.6	7.2
120	10.8	12.3	12.7	10.6	11.4	13.2	11.9	10.9	8.3	12.2	11.3	8.9	9.3	12.2	9.3	9.1
180	12.3	12.8	13.5	11.4	12.4	12.9	12.5	12.0	10.8	12.7	13.2	10.3	10.6	12.6	10.4	10.0
240	12.5	12.4	14.6	13.1	13.6	13.3	12.8	11.9	11.8	12.4	13.9	11.2	11.6	12.3	11.1	10.2
300	13.4	12.0	14.9	13.2	13.0	12.8	13.0	11.8	12.9	12.7	14.0	11.5	12.1	12.3	11.9	10.9
									Test Weight							
0			60.6				60.7				60.0				60.0	
60			58.0				61.8				60.2				60.3	
120			55.9				60.9				57.2				60.4	
180			54.6				61.0				54.1				59.7	
240			53.9				59.6				51.4				59.1	
300			53.2				59.6				52.8				58.1	

Table 11. Bushels of response per inch of water above an assumed 50 bushel dryland yield. Lind, 1970.

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

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

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

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

TREES AND SHRUBS FOR DRY-LAND PLANTING

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

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

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

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

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

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

Table 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 Rocky Mt. Juniper	Evergreen	12 ft.	27 ft.

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