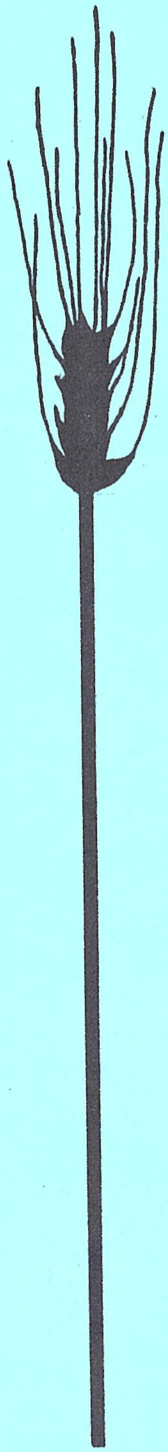

45th Annual

FIELD DAY

Dry Land Experiment Station

Washington Agricultural Experiment Stations
Washington State University

Institute of Agricultural Sciences
June 29, 1961

INTRODUCTION

The Dry Land Experiment Station, one of seven Washington Agricultural Experiment Stations, was established in 1910 near Ritzville. Largely through the efforts of Spokane businessmen, the Milwaukee Railroad, and Adams County, a site was leased from Adams County approximately 3 miles northeast of Lind. Buildings were erected, and the Station moved to its present location in 1915.

Originally, the Station was operated with county, USDA, and state funds. At present it is supported entirely by state funds. The farm consists of 320 acres of land. Approximately 260 acres are devoted to crop production experiments. The remainder consists of grass and rough land.

Early in 1949, Adams County deeded 2.06 acres to the Board of Regents of Washington State University. There the new state-financed office and greenhouse buildings were constructed. The Dry Land Experiment Station has carried out a continuous program of research since its establishment.

Experiments are conducted cooperatively with the departments of the Main Experiment Station at Pullman; Soil Conservation Service and Bureau of Plant Industry, USDA; and with the U. S. Weather Bureau, Department of Commerce.

Field Day is held each June to acquaint farmers, ranchers, and townspeople of central Washington with our work and to report on the experiments in progress. You are invited to attend these field days, or are welcome at any time.

Walter L. Nelson, Superintendent

CLIMATIC INFORMATION

Table 1 gives the annual rainfall at the Dry Land Experiment Station for the past 44 years. Table 2 shows that approximately 90 per cent of the rainfall is between October 1 and June 30, and 50 per cent of all rain falls between October 1 and January 31. This rainfall pattern coincides with the normal winter wheat growing season. Low evaporation during much of this period increases the efficiency of the moisture storage and usage during both the fallow and crop year.

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, a continuous record of soil and air temperatures, and precipitation is kept by means of automatic recording instruments.

Table 1. Annual rainfall at the Dry Land Experiment Station, Lind, Washington, for crop year September 1, to August 31, from 1916-1960

1916-17	7.60	1930-31	6.91	1944-45	10.05
1917-18	6.64	1931-32	9.78	1945-46	11.82
1918-19	8.10	1932-33	8.39	1946-47	8.02
1919-20	6.56	1933-34	9.79	1947-48	22.71
1920-21	7.01	1934-35	7.48	1948-49	7.00
1921-22	6.97	1935-36	8.09	1949-50	9.89
1922-23	10.90	1936-37	8.93	1950-51	9.85
1923-24	6.62	1937-38	11.89	1951-52	8.11
1924-25	8.32	1938-39	5.32	1952-53	7.71
1925-26	6.65	1939-40	13.01	1953-54	7.98
1926-27	12.65	1940-41	18.00	1954-55	7.40
1927-28	10.83	1941-42	12.29	1955-56	11.50
1928-29	5.77	1942-43	11.65	1956-57	7.73
1929-30	4.80	1943-44	8.60	1957-58	10.10
				1958-59	10.71
				1959-60	9.23

44 year average 9.30
Rainfall September 1, 1960 to June 1, 1961 11.45

Table 2. Average Monthly Rainfall in Inches 1920-60 Inclusive, Dry Land Experiment Station, Lind, Wash

September	0.60	January	1.08	May	0.77
October	0.96	February	0.91	June	1.00
November	1.12	March	0.72	July	0.21
December	1.23	April	0.62	August	0.30

RESEARCH ON CEREAL CROPS

The objective of the Dry Land Experiment Station cereal breeding and testing program is to develop new varieties of cereals adapted to the Big Bend area, where annual rainfall is from 8 to 13 inches. The program includes testing new varieties and selections developed at other experiment stations throughout the Midwest and Pacific Northwest, and breeding of new varieties. Actual breeding and selection are done on the station.

Final testing is at selected locations in the Big Bend. These sites are presently 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 location 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 Station will determine the value of any new selection for the Big Bend area.

Barley

Research with barley is limited to variety testing of standard varieties and new selections from WSU and other experiment stations in the Western states. Regional nurseries of barley and durum spring wheat are grown on the station, and a limited number of barley varieties at the off station sites.

The Station has under increase a small acreage of Unitan spring barley for possible release in 1962. This variety has been consistently higher yielding than Gem in trials on the Station. By the end of this season data will be available for a decision on the release of Unitan.

To facilitate harvest of experimental cereal plots, a plot combine was developed at this station. The combine was engineered and built to specifications by Carl Beckley, Benge, Washington. The combine was financed by a grant of $6,000 from the Hay and Grain Fund of the Washington State Department of Agriculture, and by donations of $545 from County Wheat Associations and other donations. With this combine, a crew of two can harvest as fast as a crew of six by hand methods.

Winter Wheat

The winter wheat breeding and testing program is pointed towards developing varieties of good quality adapted to early deep seeding. About seventy advanced generation lines of Burt X Itana which are resistant to stripe rust are now in yield trials. Further testing for yield and quality during the next two years will determine if any of these selections is adapted to the Big Bend and should be released. Many other crosses in various stages of development show good promise for the future. Most of these crosses show good to excellent stripe rust resistance and have adequate smut resistance in their breeding.

Smut testing is in cooperation with USDA at Pullman under the direction of Dr. C. S. Holton. Quality testing is conducted at the Western Wheat Quality

Laboratory under the direction of Dr. M. A. Barmore, at Pullman. These cooperating agencies make possible a better and more rapid evaluation of selections in the breeding program.

Since 1956, three varieties of winter wheat have been released to farmers in the Big Bend Area. These varieties are Columbia, Burt, and Itana. The varieties are described in Extension Circulars Nos. 275, 284, and 297 respectively. Table 3 compares yields of these varieties in percentage of Kharkof (Turkey) and of other varieties for the locations indicated and for the number of years grown at each location.

Table 3. Comparative Yields of Winter Wheat Varieties in Per Cent of Kharkof Grown at Lind, Harrington, Waterville, and Horse Heavens, for Number of Years Indicated, Dry Land Experiment Station, Lind

Variety	Lind		Harrington		H. Heavens		Waterville		Ave. all Locations
	Years Grown	Yield, % of Kharkof	Years Grown	Yield	Years Grown	Yield	Years Grown	Yield	
Omar	3	127	5	130	4	136	3	120	128
Burt	6	132	9	124	4	131	5	121	127
B-9, CI 13448	1	146	1	148	1	99	1	108	125
Elgin	17	112	9	122	4	137	6	114	121
Brevor	9	114	9	115	4	125	6	113	117
Itana	6	117	9	111	6	119	5	117	116
Cheyenne	3	118	4	116	4	120	3	105	115
Golden	19	98	9	96	4	110	6	133	109
Columbia	6	95	9	106	6	113	5	117	108
Tendoy	3	105	3	107	3	114	3	108	108
Rio	6	100	9	101	6	102	5	100	101
Kharkof	20	100	9	100	4	100	6	100	100

Spring Wheat

The spring wheat program at the Dry Land Experiment Station has four main objectives:

1. Test and introduce available spring wheat varieties and breeding material from other areas.

2. Improve superior spring wheat varieties by various breeding methods.

3. Incorporate resistance to leaf and stem rust in varieties adapted to the Big Bend Area.

4. Improve the quality and protein content of spring wheat varieties adapted for this area.

Awned Onas, Marfed, Idaed, Baart and Henry have been crossed with good quality, high yielding spring wheat selections. Selections with good milling and baking quality from these crosses are now in state regional yield trials. Several thousand additional selections are being tested for quality and will be included in future yield trials. Preliminary milling and baking quality are tested on a 5 - gram milling--about 150 kernels. This can be done on an individual plant basis; selection for quality can start about 4 to 5 years earlier in the breeding program. These new micro technics permit selection for quality at the same time preliminary selections for other agronomic characteristics are made.

Considerable emphasis is being placed on breeding for protein and yield. Recent research has shown that both high protein and high yield can be attained in the same variety. Many of the recent crosses have included parents which can produce high protein with good yield. It appears that some progress has been made in this area.

Several of the new selections have high protein, good bread quality, and yield comparable with Marfed. These data are from 2 years of state wide yield trials. The 1961 data should determine if these selections will be considered for further testing and increase.

Table 4 shows the yields of six spring wheat varieties grown at Waterville, Harrington, Horse Heavens, and Lind for 7 or more years. The average yield figures at all locations show Marfed and Lemhi are the highest yielding varieties for these years. Both of these varieties have poor quality at high protein and are not recommended for low rainfall areas. Marfed is recommended for areas where precipitation exceeds 11 inches.

Variety recommendations for eastern Washington for wheat, oats and barley are given in Extensions Misc. Publication 14, available from your County Agent.

Table 4. Yield of Spring Wheat Varieties Grown at Harrington, Horse Heavens, Waterville and Lind for Number of Years Indicated. Dry Land Experiment Station, Lind, Washington

Variety	Harrington 10 yrs.	Horse Heavens 7 yrs.	Waterville 8 yrs.	Lind 8 yrs.	% Baart Yield, All Locations
Marfed	32.2	23.4	31.5	23.6	112
Lemhi	30.3	20.8	30.9	21.4	106
Federation	30.0	20.8	29.2	21.4	104
Idead	32.1	21.0	26.9	19.9	103
Baart	28.4	20.6	27.9	21.0	100
Henry	30.5	19.9	26.1	19.3	98

WHEAT DISEASES

Wheat disease studies at the station are conducted by personnel from the main station. During the past 2 years, two diseases have been studied. Dr. Walter Hendrix, Plant Pathologist, Pullman, has investigated stripe rust of wheat. Mr. John Hoes, Research Assistant, Pullman, has studied the fungi of wheat roots and crown.

Dry Land Root Rot Studies

A study of the fungi of dry land wheat roots and crowns, sponsored by the Washington Wheat Commission and Washington State University, is completing its second year. This study has two major phases; a census of the fungi, and a special study of those that are unknown or little known.

The census is a recording of the fungi as they are obtained from the plants, including the date or time of the year, the part of the plant, such as crown, seminal root, crown root, and the location in the soil, such as at 1 inch or 4 inches deep. In this way some idea of the sequence of fungi normally present in wheat plants is sought. There have been several studies of this type in different wheat regions of the world, but they have usually not been as systematic as this one. The main reason for this part of the work is that we believe that the dry land wheat region of Washington is a special region; studies of other areas might have little value here.

The "little-known" fungi of the wheat roots are emphasized in the hope that new and different fungi may be found that will explain the cause of the dry land root rot, or premature blight of certain varieties that occurs in a wide region in central Washington. It is quite possible that some of the fungi ignored in the past really play a part in the root and crown-rot disease complexes.

This project will be completed this year and funds for future work are not available from the grantors. Over 5500 fungi cultures were studied. Most of these were common fungi. One new fungus was weakly pathogenic on wheat. This fungus is not believed to be associated with the common dry land root rot disease.

Stripe Rust Studies

During the past 2 years Dr. Walter Hendrix has studied stripe rust of wheat extensively. He has made numerous surveys and samplings to determine at what temperatures and conditions the disease is active and will infect wheat. These studies are basic to a understanding of the possibilities of the development of stripe rust epidemics.

Stripe rust is a defoliant type of disease. In mild infections a few orange-yellow stripes develop and portions of the leaves are killed. In heavy infections the whole leaf becomes yellow and later dies. The fungus will invade the heads in severe infections and cause additional damage. Under the worst possible conditions, losses of 50 per cent or more can be expected. Fortunately, however, such conditions are rare in the Pacific Northwest. Last year's experience indicates that losses do not exceed much more than 25 per cent. In most fields, these losses may be half that much.

In the Pacific Northwest, virtually nothing has ever been done to establish actual damage from stripe rust. Studies were initiated in the fall of 1960 by Dr. Hendrix on the Station and at other locations to study the actual damage by stripe rust. Results of these studies and comparison of yields in normal years will give a more sound basis for estimating the actual damage.

Application of foliar sprays as protectants were made with six chemicals. Included were a zinc compound, an experimental nickel compound, ammonium bisulfite, ammonium polysulfide, a colloidal copper compound, and an experimental sulfur compound. Only one of the chemicals gave visual evidence of effective control with one or more applications. Unfortunately, this compound was toxic to the plant at the rates used and thus appears to have little commercial promise. Yields will be taken to determine the effectiveness of the treatments. Evidence to date indicates that there is no economical control by chemicals for stripe rust.

Common varieties susceptible to stripe rust are Itana, Columbia, Omar, Elgin, Elmar, Baart, Henry, Federation, Lemhi and Marfed. Varieties showing fair to good resistance to stripe rust are Burt, Rio, Turkey, Cheyenne, Tendoy, Brevor and Idaed. B-9, (CI 13448) a short-straw variety considered for release has good stripe rust resistance. In general, barley and rye are resistant to stripe rust.

Plant breeders have been selecting for stripe rust resistance in the wheat breeding program at this Station and at the Main Experiment Station whenever stripe rust occurred. Resistance to this stripe rust is in most of the selections in the breeding program. Many selections are immune.

SOILS AND FERTILIZER STUDIES

The soils and fertilizer research at the Dry Land Experiment Station is conducted cooperatively with the Agronomy Department, WSU, Pullman. This research is now under the leadership of Dr. Fred Koehler. During the past 10 years, extensive studies have been conducted on rates, date, and methods of fertilizer application. The results of these studies are reported in Washington Agricultural Experiment Stations Bulletins 602, 608, and 609.

Bulletin 602 summarizes 5 years' results from 112 fertility experiments in eastern Washington. This bulletin gives detailed results of these experiments and recommendations for nitrogen, sulfur and phosphorus for each rainfall area. For recommendations for your local area, see your County Agent. He is kept up to date on fertilizer recommendations.

Bulletin 608 summarizes 5 years of comparisons between annual cropping and summer fallow in the 10 to 15 inch rainfall areas. The average yields of wheat from annual cropping at optimum fertilizer rates were 13 bushels per acre at Ritzville, 23 at Harrington, and 29 at Dusty. Although the yield of wheat was too low at Ritzville, the yields at Harrington and Dusty were high enough to consider annual cropping.

Bulletin 609 reports on the relationship of wheat yield, available moisture and available nitrogen. These data show that about 3 pounds of nitrogen per acre are needed to increase the yield of wheat 1 bushel per acre, where nitrogen is limiting yield. Four inches of moisture is necessary to grow wheat to heading stage and each additional inch increases the yield by approximately 6 bushels per acre.

To date, experiments with sulfur or phosphate fertilizer have not given any significant yield increase, except in isolated areas where deficiencies are known. The Station will continue testing with these elements to determine when they might be used profitably in wheat production.

Research is being done on soil and fertilizers to determine water and nitrogen requirements of the growing wheat plant. Soil moisture is measured periodically during the growing season at 1 foot intervals to a depth of 8 feet. Plants are sampled periodically to determine nitrogen uptake. Water and nitrogen requirements of the wheat plant are measured at different stages of plant growth, and at different rates of fertilizer application. Results of these studies will help determine how fertilizer and soil moisture can be used to produce wheat more efficiently.

WHEAT MANAGEMENT STUDIES

Over the past 30 years, management studies at the Dry Land Experiment Station have included various methods of tillage, fertilizer trials, annual cropping, timing of seeding and fertilizer application, and rate of seeding. One of the striking features this research has shown is now fast the management problem changes. Within the past 10 years, new machinery, new varieties, and the use of fertilizer have completely changed management in the low rainfall area of eastern Washington.

The short straw varieties of the future will require different management if we are to reach new maximum yield levels. Farmers using new equipment adapted to stubble mulch farming, with proper fertilization, early seeding, and new varieties have increased wheat production 30 to 50 per cent in the low rainfall area.

In the Lind area, wheat production in 1959 and 1960 was the largest on record. This record is even more remarkable because it was produced on only 65 per cent of the land, and during years of less than average rainfall. This is a 35 per cent increase in yield over the previous record yield of 1942, not just 35 per cent above average.

In 1959-60 studies at the Dry Land Experiment Station evaluated the response of Burt and Itana to three different dates of seeding at three levels of fertility. Land was prepared with the following stubble mulch program:

1. Fall stubble chisel to depth of 8"

2. Early April sweep operation at a 5 inch depth

3. One or two rod weeding operations at a 3 to 4" depth for cheat grass and volunteer wheat control

4. Early May fertilizer application with shanks

5. Compaction with either rotary hoe or skew treader pulled in packing attitude

6. Shallow rod weeding for weed control as needed.

This stubble mulch program maintained a moisture level in the fallow at a depth satisfactory for deep seeding up to September 15 without additional fall moisture.

Tables 5 and 6 summarize the response to the date of seeding and to the levels of fertilizer.

Table 5. Average Increase in Yield in Bushels per Acre at Different Dates of Seeding, 1959-60, Dry Land Experiment Station

Date of Seeding	Average yield increase bu/a Burt	Itana
August 15+-	12.8	9.3
September 10+-	6.8	7.5
October 15	0.0	0.0

Table 6. Average Increase in Yield in Bushels per Acre at Different Rates of Nitrogen, 1959-60, Dry Land Experiment Station

Rate of Nitrogen	Average yield increase bu/a Burt	Itana
0#, Check	0.0	0.0
30#, S.F.[a]	5.5	4.5
30#, S.D.[b]	7.5	3.7
60#, S.F.	8.6	5.7

[a] May application in Summer fallow.

[b] April application in wheat, side dress.

In this study, the fertilizer response was about equal at each of the three dates of seeding. This yield response was in addition to the yield increase from date of seeding. The yield of Burt was increased 76 per cent by seeding August 15, and applying 60 pounds of nitrogen, when compared with no fertilizer treatment and seeding October 15. This same treatment increased Itana yield 52 per cent. Other experiments in 1960 indicate seeding earlier than August 15 increased fertilizer requirements by as much as 40 pounds per acre. July seeding increases the hazards of yellow dwarf, heat damage, wheat streak mosaic, and root rot.

Table 7 gives the average yields of three rates of seeding at two dates for the varieties Burt and Itana, in 1959-60. The 60# seeding rate decreased the yield at the August 15 seeding date. At the October 15 seeding date, both 45# and 60# rates were about equal. The 30# rate may be a little light for maximum production.

Table 7. Average Yield of Wheat at Three Rates and Two Dates of Seeding, 1959-60, Dry Land Experiment Station

Date	Variety		Rate of Seeding in lbs/acre 30	45	60
			bu.	bu.	bu.
August 15	Burt		38.4	39.1	34.3
	Itana		37.2	38.7	35.8
		Av.	37.8	38.9	35.1
October 15	Burt		31.0	34.1	32.5
	Itana		28.5	28.3	29.5
		Av.	29.8	31.2	31.0

On the basis of these results and other observations and trials not reported here, we recommend seeding August 15 to September 10; fertilize with 35 to 50 pounds of nitrogen, applied either in the summerfallow or as a side dressing. Seeding rates of 30 to 45# per acre are recommended for early planting.

Short-Straw Wheat

We have experiments comparing date of seeding, rates of nitrogen fertilizer, and rates of seeding for the short straw selection C. I. 13448. These trials are located at three off-station locations with a rainfall range of 9 to 13 inches. We also have trials on the station.

Results from these studies in 1960 did not show any major differences in the response of the short straw variety to these management stresses when compared with other standard varieties. Previous work by Dr. Koehler indicated a greater yield response to early seeding by the short straw types in the higher rainfall areas. Since this selection has poor emergence characteristics from deep seeding, it is reasonable to assume new management problems will show up with early seeding. At least two more years of data are needed before any general recommendations can be made for the short straw variety C. I. 13448 in this lower rainfall area of Eastern Washington.

STUDIES ON THE CONTROL OF CHEATGRASS IN WHEAT

Powell Anderson and Tom Muzik

Through a financial grant made available by the Washington Wheat Commission to the Department of Agronomy, Washington State University, the research program on selective control of cheatgrass in wheat was expanded in 1959. Extensive field experiments were located on the Station, McGregor's Ranch at Hooper in 1960, and again in 1961 at these locations and at two additional places near Dayton. Of the chemicals tested, Simazine and Atrazine show considerable promise. The time at which these materials are applied is extremely important. Applied too early they will kill the wheat crop; applied too late they will have no effect on the cheatgrass. In general, Simazine is more effective when applied in the late fall or early winter, while Atrazine is most effective applied later in the winter or before early March.

Before the use of these materials can be recommended for the selective control of cheatgrass in wheat it is necessary to learn more about the requirements which determine the relatively safe period in which they may be used. In 1961, experiments were established on the Station designed to determine the effects of stage of growth of wheat and cheatgrass as related to the date of application of Simazine and Atrazine. Preliminary results indicate that this may be an important factor in the application of these two chemicals.

Screening new chemicals to determine their value as selective herbicides for the control of cheatgrass in wheat continues. To date, none of the chemicals from the screening program appears to be much superior to Atrazine and Simazine.

Correlated with the testing of chemicals for the selective control of cheatgrass in wheat is the use of these chemicals for the control of this weed in fallow lands.

Of primary concern in the use of chemicals for either selective control of cheatgrass in wheat or for chemical control in fallow land, is the longevity of these chemicals in the soil. Both Atrazine and Simazine appear to have some residual effect at high rates of application. Research in this phase must be continued before it will be safe to recommend these chemicals.

This research program will be continued during the next crop year, financed by an additional grant from the Washington Wheat Commission and the Hay and Grain Fund of the Washington State Department of Agriculture.

FORAGE INVESTIGATIONS

Grasses and legumes are studied for adaptation to the low rainfall areas. This work is conducted by the Agronomy Department, WSU, and the Soil Conservation Service, Nursery Division, Pullman, Washington. Grasses which show promise of adaptation to this area are tested for yield, longevity, ease of establishment, stand, and other agronomic characteristics. Long time studies show that crested wheatgrass will produce more forage in established stands than any other species of grass in the low rainfall area. Production averages less than 1000 pounds of forage per acre at Lind. Row spacings of 14" appear to be the most satisfactory for solid stands. A summary of forage studies in Washington is given in Stations Circular 267, November, 1960 revision. This is available from your County Agent.

In 1956, a source nursery was established at the Dry Land Experiment Station. This work is under the direction of C. L. Canode and E. V. Horning, ARS, USDA, Pullman. This nursery was established to supply material to initiate a breeding program to develop grass varieties better adapted to the dry land areas of Washington. Varieties, experimental seed lots, and seed from individual plant selections of wheatgrasses are exposed to natural climatic selection for 3 to 5 years. After natural selection has eliminated or at least indicated the plants that are not well adapted, the remaining plants will be carefully screened. We should thus find material that appears outstanding in drought resistance, seed production, and quality.

Seed will be harvested from selected plants and planted to provide second cycle source material. Vegetative material will be taken from each plant selected and a permanent nursery will be established from the cuttings. The selected plants from this nursery will in this manner furnish the basic material for the breeding program.

The planting in the north half of the field was made December 14, 1956 with seed of Greenar intermediate wheatgrass (*Agropyron intermedium*), Whitmar bluebunch wheatgrass (*Agropyron inerme*), and three experimental varieties of bearded bluebunch wheatgrass (*Agropyron spicatum*). All of these species are well adapted to the dry land area of central Washington. But all have undesirable characteristics that must be overcome before they can be considered highly desirable or competitive with Nordan crested wheatgrass.

The south half of the field was planted October 30, 1957 with seed from a large number of individually selected plants of intermediate, inerme, and spicatum. Most of these plants were selected from the dry land areas of central Washington for their outstanding agronomic characteristics.

TREES AND SHRUBS FOR DRY-LAND PLANTING

Several species of trees and shrubs are included in the Station forestry project for farm-home landscaping and windbreaks. The first plantings are over 30 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.

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 Experiment Station and the Department of Forestry and Range Management, Washington State University.

A standard dry-land windbreak planting consists of minimum of five rows. When properly established, these give excellent protection from the winds. Results to date indicate that Caragana is still the best erect shrub. Blue leaf honeysuckle and Nanking cherry are showing considerable promise. 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 most promising deciduous tree. Green ash and Chinese elm are good but they do not show the promise of black locust. Austrian pine is the outstanding evergreen tree, being superior to both Scotch and Ponderosa pine. Norway spruce, Douglas fir and Blue spruce can be grown but require more care and have a much slower growth. Rocky Mountain juniper is showing the most promise in this group.

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. Transplanted evergreen stock has given better survival than seedling stock. Although transplanted stock is more expensive, the superior survival will compensate for the extra cost.

Table 8. Standard Species, Arrangement, and Spacing of Trees and Shrubs for Windbreak Plantings in the 8-10 Inch Rainfall Area

Row No.	Species	Growth habit	Spacing in row	Minimum distance from next row[a]
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	Evergreen	12 ft.	27 ft.
	Scotch pine			
	Ponderosa pine			
	Norway spruce			

[a]Rows can be spaced wider apart if cultivation equipment requires it.