47th annual field day Dry Land Experiment Station, Lind. 1963

INTRODUCTION

The Dry Land Experiment Station, one of eight 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. Elevation is 1625 feet at headquarters but varies from 1550 to 1705 feet over the acreage.

A summer fallow-cereal crop-summer fallow rotation system is used with cereals, the only crops grown on plot land. Other than wheat, the crops tested include barley, grasses and forages, oil crops, and plant introductions.

The station is primarily a site for applied research with concentration on wheat breeding and testing, soil management, and management of cereal crops. Limited fundamental research is conducted in cooperation with the Plant Pathology, Agronomy, and Entomology Departments of Washington State University. Such research is done under supervision of staff members from WSU. Other cooperators are the Soil Conservation Service. Bureau of Plant Industry, and the U.S. Weather Bureau.

Field Day is held each June to give the farmers, ranchers, and townspeople of central Washington a chance to see the experimental work and to report on the work in progress. Visitors are welcome at the station at any time.

Walter L. Nelson, Supt.

CLIMATIC DATA

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.

Table 1 lists the average temperatures and precipitation for each month. The average frost free period (32°) is 143 days, from 14 May to 4 October. Extremes of temperatures and rainfall recorded at this station are: maximum high, 113°, minimum low -26°, maximum annual rainfall 22.7", minimum annual rainfall 4.8". Average winter snow fall is about 12", but most of the winter precipitation is in the form of rain.

Table 1. 40 Year Average Temperature and Precipitation at Dry Land Experiment Station, Lind

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

Approximately 90% of the rainfall is between October 1 and June 30. This rainfall pattern coincides with the normal winter wheat growing season. Low evaporation rates during much of this period increase the efficiency of the moisture storage and use during both summer fallow and the crop year.

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 less than 13 inches. The program includes testing new varieties and selections developed at other experiment stations throughout the Midwest and Pacific Northwest, and breeding 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 Volmer and Bayne farm, Horse Heaven Hills.

All experimental work at the outlying locations is conducted by the same methods as the work at the station. Fifty to sixty varieties and new selections from breeding nurseries are tested at these locations. Farmers in these areas are urged to visit the plots on the 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. Regional nurseries of barley are grown on the station, and limited number of barley varieties at the off station sites.

In 1962, Unitan spring barley was released to Washington growers. It is recommended for areas of less than 15 inches of rainfall. Unitan is a cross of Glacier x Titan. The cross and preliminary selections were made by R. F. Eslick at Montana State College, Bozeman. It was released in 1960 to Montana growers. Unitan is a six-rowed, semi-smooth awned, white chaffed with white kernel, feed barley. Kernel characteristics are similar to Gem. The head is slightly nodding, long, and semi-lax. The beards tend to drop off if allowed to stand. It matures 3 to 6 days later than Gem. Unitan is 1 to 3 inches taller than Gem, and similar in lodging characteristics. Unitan has a more even top line than Gem and should be easier to combine.

Table 2 compares the yield of Unitan to Gem, Piroline (a high yielding two row variety under test), and Heines Hanna. The average yield of Unitan was 3 bushels higher than Gem for the 25 trials. In the Great Plains Regional Barley Nursery, Unitan was the highest yielding 6 row barley in 5 out of the 6 years tested and was second the other year. It has the highest average yield of all enteries since 1957. These data indicate Unitan has a wide range of adaptability. Seed supplies for 1964 will be adequate to meet the farmer demands. About 10 tons of foundations seed will be available to registered seed growers in 1964.

Table 2. Yield in Bushels of Four Barley Varieties at the Locations Listed and for the Number of Years Listed

	Lind 6	Pullman 6	Dusty 4	Walla Walla 3	Horse Heavens 2	Harr-ington 2	Water-ville 2	Av. of 25 trials
Unitan	39.1	78.5	58.5	72.7	28.8	47.8	50.4	56.5
Gem	35.8	73.6	58.4	71.1	33.5	48.6	40.6	53.9
Piroline	36.3	75.5	52.3	81.8	30.2	43.7	38.3	54.0
H. Hanna	32.2	67.4	53.1	64.3	23.8	39.6	35.5	48.0

Winter Wheat

The winter wheat breeding and testing program is designed to develop varieties of good quality adapted to early deep seeding, primarily of the hard red bread type. The program has progressed to a point where a new hard red variety from the cross of Burt x Itana is in the final stages of screening. One will be selected from a dozen selections with yield potential equal or better than Burt. All of the selections have good early seeding emergence characteristics. The stripe rust resistance is about equal to the level of resistance of Gaines, and is superior to Burt. However, none of the selections has resistance to stripe rust in the seedling stage. Milling and baking quality are superior to Rio and Turkey. The earliest date of release for one of these selections will be 1965.

Stripe rust continues to be the major disease threat in dry land areas. Since there is no adequate control except through variety resistance, breeding for resistance is a major part of the program. The early build up of stripe rust is in the fall or early spring. None of our commercial varieties has resistance in the seedling or early growth stages. Seedling resistance to stripe rust is available, but no variety with this resistance is adapted to our wheat producing area. This resistance has to be added to the adapted varieties and is in early generation selection in the breeding program. Further improvement through back crossing will be necessary before this resistance can be added to adapted varieties.

Testing for disease resistance is in cooperation with the Plant Pathology Department, WSU, Pullman. Quality testing is conducted at the USDA Western Wheat Quality Laboratory, WSU, Pullman. These cooperating agencies make possible a better and more rapid evaluation of selections in the breeding program.

Since 1956, five varieties of winter wheat have been released to farmers in Eastern Washington. Columbia and Itana hard red varieties, and Burt, a hard white variety, are recommended for the low rainfall areas. Omar, a soft club, and Gaines, a common white variety, are recommended for the intermediate and high rainfall areas. Extension circulars describing each of these varieties are available. Table 3 compares the yield of these and other varieties in percentage of Kharkof (Turkey).

Gaines, a short-strawed, bearded, white chaff wheat developed by Dr. O. A. Vogel, USDA, Pullman, was released in 1961. It has mature plant resistance to stripe rust, and will take rust in the early growth stages. It is as smut resistant as Burt. Normal plant height in the 10 to 13" rainfall area varies from 24 to 32". Gaines is a pastry type wheat with acceptable milling and baking quality.

Gaines is not as adapted to early seeding as Omar, Itana, and Columbia are. Gaines requires a higher moisture content in the soil for good germination. It is quite similar to Burt in this respect. During the past two years, good stands were obtained when Gaines was deep seeded in good moisture. Gaines is slower to emerge than Omar or Itana.

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

Variety	Lind		Harrington		H. Heavens		Waterville		Av. all Locations
	Years Grown	Yield % of Kharkof	Years	Yield	Years	Yield	Years	Yield	
Gaines	3	137	3	152	2	108	3	135	133
Burt	8	126	11	125	5	124	7	125	125
Omar	5	112	7	121	5	124	5	122	122
Elgin	19	113	11	120	5	125	8	117	118
Brevor	11	113	11	117	5	119	8	121	118
Cheyenne	5	118	5	120	5	119	5	111	117
Itana	8	112	10	109	7	115	7	115	113
Tendoy	4	110	4	110	4	112	4	112	111
Columbia	8	93	10	104	7	109	7	112	104
Golden	21	100	11	96	5	111	8	102	102
Rio	8	98	10	101	7	102	7	102	101
Kharkof	22	100	11	100	7	100	8	100	100

Spring Wheat

The spring wheat program at the Dry Land Experiment Station includes the testing and introduction of available spring wheat varieties from other areas, and the improvement of spring wheat varieties through breeding. Present emphasis in on incorporating resistance to leaf, stripe rust, and stem rust is adapted varieties, and improving the quality and protein content of these varieties. Considerable emphasis is being placed on breeding for protein and yield. 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.

In the low rainfall area, spring wheat usually produces higher protein than winter wheat. A high yielding spring variety of bread quality would be of particular importance. Table 4 shows that the yield of spring wheat averaged

20 bushels per acre less than winter wheat during the last three years. Spring wheat is a second choice crop and will be seeded only when winter wheat fails for lack of moisture or winter kill. The development of a variety of spring wheat that yields more closely to winter wheat would be a major development for the dry land area.

Table 4 Comparative yields of Spring and Winter Wheat Grown at Lind, Harrington, and Waterville 1960-62.

Variety	Lind	Harrington	Waterville	Av.
Gaines	43.7	56.4	51.6	50.6
Burt	38.3	46.9	46.9	45.9
Omar	33.8	40.4	45.6	39.8
Marfed	21.9	29.4	32.8	28.1
Idaed	22.2	27.0	29.6	26.1
Baart	18.3	25.4	26.8	23.4

The best of the new selections are Karn x Henry, Henry x Burt, and Awned Onas x Burt. Another year of data are necessary before these selections will be advanced to the final yield and quality testing. These are high protein bread type spring wheat selections with excellent milling and baking qualities.

Table 5 shows the yields of six spring wheat varieties grown in the Big Bend area for the last 8 years or more. Marfed is the highest yielding variety. It has rather poor quality at high protein, and is only an average milling variety. It is recommended for eastern Washington, and generally for areas of more than 11 inches of rainfall.

Table 5 Yield of Spring Wheat Varieties Grown at Harrington, Horse Heavens, Waterville, and Lind for Number of Years Indicated. Dry Land Experiment Station

Variety	Harrington 11 years	Horse Heavens 8 years	Waterville 9 years	Lind 9 years	% Baart Yield, All Locations
Marfed	33.6	22.5	32.1	23.8	115
Lemhi	31.8	20.1	31.7	21.9	109
Idaed	32.3	20.5	27.5	20.1	104
Federation	30.5	20.5	29.2	21.8	105
Baart	28.9	20.1	27.6	21.0	100
Henry	30.5	19.8	25.7	19.4	98

WHEAT DISEASES

Snow mold has been a serious problem on winter wheat in Douglas county and surrounding area where snow cover over long periods during the winter are common. A project to study this disease is financed by the Washington State Wheat Commission. The disease studies and variety screening are done by William R. Fischer, who is stationed at the Tree Fruit Experiment Station at Wenatchee.

In conjunction with the wheat breeding program at Lind, a technique has been developed at Wenatchee whereby, under artificial conditions, large quantities of winter wheat varieties can be screened successfully against snow mold. The project is now developed to the stage that actual selection of hybrid populations will be started this fall.

Young plants grown in 6-inch pots in the greenhouse or out-of-doors are moved to a special "hardening" room under artificial lighting at near freezing temperatures for 2 weeks. Snow mold inoculum grown on a sand-bran medium is then distributed around the plants in each pot. The plants are then covered with a wad of dampened cotton which presses the leaves in contact with the soil surface, simulating the effects of a deep snow cover. The pots are transferred to shallow trays of water and left in complete darkness at 33 - 36° F. until disease develops to the desired degree. The pots are then returned to the greenhouse for comparison of leaf surface injury and recovery ability.

To date, most of the work has been with the black speckled mold, *Typhula idahoensis*. Most commercial varieties die within 7 weeks after inoculation. A number of foreign varieties obtained from the World's Collection of Small Grains can survive 10 weeks or longer.

This system is being expanded to handle up to 4,320 pots (about 22,000 seeds) per year. This will accommodate the F_2 and F_3 generation plants from seed currently being produced from crosses of the more resistant varieties with commercial breeding stock. It is hoped that through these efforts a suitable wheat may be developed for the more severe snow mold areas of the State.

A main advantage of this artificial technique over field testing in actual snow mold country is that one doesn't plant acres of seed in the fall only to see the plants come through unscathed following an open winter. This is what occurred last winter in all three snow mold nurseries in northern Douglas County in which over 12,000 varieties were being screened. However, in this instance we were able to obtain some important data on winter hardiness.

In the chambers, it is possible to create a uniform level of inoculum of a known pathogen, uniform temperature and humidity, and to control the exact length of the disease development period in order to obtain the most meaningful data.

Foot Rot Diseases

Foot rot has increased in the Big Bend area in recent years. Early seeding and the cold wet springs have been favorable for the development of this disease. In the fall of 1962, G. W. Bruehl, Experiment Stations Plant Pathologist, established a foot rot disease nursery at Lind on early seeded

Gaines wheat and other varieties. Using information gained from the exploratory nursery last year, about 4 acres of wheat was inoculated this year to determine disease damage, improve inoculation technics, and study the effects of fall and spring tillage on the disease.

The Dry Land Experiment Station has been free of foot rot (strawbreaker) for years. A method of producing foot rot on clean land will permit accurate evaluation of fertilizers, tillage practices, dates of seeding and varieties as the same practices can be compared with and without foot rot. In this way, more reliable information, than educated guesses can be obtained.

In the summer of 1962 sterilized oat grains, barley, rice hulls, and wheat straw were inoculated with pure cultures of the foot rot pathogen, Cercosporella herpotrichoides. The fungus was allowed to grow on these materials for 2 months. The inoculated materials were then spread out, dried, and stored for use.

Starting in October, the inoculum was scattered uniformly over different parts of two fields at Lind. Examination of the inoculum revealed that an abundance of spores was produced from November until mid-April. By mid-April it was apparent that the technique had worked, as foot rot lesions were then present on the wheat.

The oat kernels are best. They produce many spores, and they are easily spread with a cyclone seeder. We cannot expect weather as favorable as that of the 1962-63 season in all years, but we believe we have a useful technique that should implement a many-fronted study of foot rot.

Various spring and fall side-dress fertilizer treatments, and spring tillage with a skew treader were applied to the treated and non-treated area of the experiment. Spring tillage markedly increased early foot rot symptoms. Data from these trials will be valuable in determining further research and the actual yield effects of tillage on foot rot incidence.

Stripe Rust

Stripe rust continues to be one of the most serious wheat diseases in the Pacific Northwest. In the fall of 1962 the disease was widespread all over the entire wheat growing area of the Pacific Northwest. The severe winter leaf injury and winterkill killed most of the leaves that were infected, except in eastern Oregon where snow cover protected the wheat. Heavy infection of stripe rust developed in that area this spring; however, stripe rust did not become general in eastern Washington until mid-May. Hot weather arrested the development of new infection, and it now appears that stripe rust will not be a problem in the low rainfall areas of eastern Washington.

The only effective method of combating stripe rust is through breeding of resistant varieties. All of the commercial varieties have seedling susceptibility to the disease; however Gaines, Brevor, Burt, Rio, Cheyenne, Tendoy and Turkey have various degrees of mature plant resistance. These varieties offer the best resistance until new varieties are developed that are resistant in all stages of plant growth.

When stripe rust infects the wheat plant early, in either fall or early spring, and continues to infect the plant through the development of the flag leaf, yields are reduced severely. In 1961, yields on the Dry Land Experiment Station were reduced at least 37% in susceptible varieties. In varieties like Burt that had some resistance, yield losses were about 15%.

Research on foliar sprays as protectants conducted during the past 3 years indicates that there is no economical control by spray. Some experimental control was obtained, and the work is being continued. But nothing in the chemical now used looks very promising.

Stripe rust research is under the leadership of Dr. W. J. Hendrix, Experiment Stations Plant Pathologist. Others working on stripe rust include Dr. L. H. Purdy, ARS, Plant Pathologist at WSU, and Dr. R. A. Allen, WSU, USDA Plant Breeder. The overall research program includes epidemiology studies, biological race studies, evaluations of varieties for resistance, and the breeding of new varieties for resistance.

WHEAT MANAGEMENT STUDIES

The Dry Land Experiment Station studies various phases of management of soil and production management in wheat production. Studies underway now include the effect of tillage on the surface moisture as it affects early seeding; effect of deep fertilizer placement on yield and protein content of wheat; effect of time of sidedress applications of fertilizer; comparison of surface and subsurface application of liquid forms of nitrogen, and the effect of row spacing on the yield of wheat. Most of these studies are in their first or second year of test and only limited results are available.

Studies last year indicated that row spacings up to 20 inches did not affect the yield on early seeded wheat at Lind. There was no weed competition in these plots last year. However, this year the plots are heavily infected with cheat grass, and the yields this year should be a good indication of this factor. Wider row spacing would be an advantage to early seeding, allowing deeper seeding without as much soil cover over the seed. Soil moisture studies indicated that the total moisture removed was about the same at all row spacings; however, the moisture was removed somewhat slower in the wider row spacings sampled midway between the rows.

Studies have been conducted at the Dry Land Experiment Station on rate and date of seeding for winter wheat. As shown in table 6, early seeding with nitrogen increased yields of Burt wheat as much as 17 bushels per acre. These data indicate that early seeded wheat uses the nitrogen and available moisture more efficiently than late seeded wheat. The data show the importance of good summer fallow practices that make it possible to seed early to get maximum yields. Management data with Gaines indicate that early seeding also favors high yields.

Table 6. Average Increase in Yield in Bushels per Acre of Burt at Different Dates of Seeding, and Rates of Nitrogen, 1959-61, Dry Land Experiment Station

Rate of Nitrogen	Seeding Date Average Yield Increase Bu/Acre		
	Oct. 15	Sept. 15	Aug. 15
0#, Check	0	2.7	9.1
30#, Summer fallow	4.5	9.1	16.1
30#, Side-dress, Spring	4.4	11.5	15.4
60#, Summer fallow	7.1	13.0	17.4

Table 7 shows that Gaines produced high yields at the higher levels of fertility. The high rate was double the lower rate, and is higher than the rate of nitrogen that gives maximum efficiency of production. The data show that Gaines has good tolerance to high rates of nitrogen, and that overfertilization does not adversely affect the yield. On the basis of these trials and others not reported here, recommendations for nitrogen on Gaines wheat have been increased. In the 10 to 13" rainfall area, rates should be increased by 25 to 40% over rates used for other varieties. In the 10" rainfall area, 50 to 60 lbs. of nitrogen per acre are recommended. In the 13" rainfall area 75 to 90 lbs are recommended. These recommendations are for early seeding. On late seedings, less nitrogen will be used and these rates should be decreased 15 to 30 lbs. per acre. In general, pre-plant or summer fallow applications are recommended in this rainfall area.

Table 7. Average yield of Gains Wheat at Two levels of Fertility at Three Locations, 1960-62, Dry Land Experiment Station

Rate of Nitrogen	Av. Yield in Bu/Acre			Av. 3
	Lind	Harrington	Waterville	Locations
35-45# (Low)	35.3	56.9	58.5	50.2
70-100# (High)	42.5	58.4	63.4	54.8

The soils and fertilizer research at the Dry Land Experiment Station is conducted cooperatively with the Agronomy Department, Main Experiment Station, 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.

Nitrogen fertilizer is the only fertilizer that has given significant yield responses on average summer fallow land in this area. Tests with sulfur and phosphate fertilizers have not given consistent yield responses, except in isolated areas where deficiencies of these elements are known. Testing of these two elements will continue to determine when it might be profitable to include them in the fertilizer program.

CHEATGRASS CONTROL

The selective control of cheatgrass in wheat was continued in 1963 through a financial grant made available by the Washington Wheat Commission. Studies this year are concentrated on screening new chemicals both at Lind and Hooper, and large scale Simazine and Atrazine trials on 14 farms in eastern Washington. In addition, trials have been conducted with chemical fallow at Pullman. The cheatgrass work for 1963 is summarized by Don Rydrich as follows:

We have no recommendations to make on the chemical control of cheatgrass in the low rainfall areas. Recommendations will not be made for the high rainfall areas until label registrations are completed.

Simazine was originally effective on cheatgrass when applied from the third weed of November to the second week of January. Simazine was extremely erratic in 1963 and injury occurred in higher rainfall areas or in areas where supplemental sprinkler irrigation was used.

Atrazine is more effective in controlling cheatgrass when applied from the second week of March when the wheat is in the three leaf stage. The effective rate of Atrazine in light soils with low organic matter is 1/2 to 3/4# per acre.

On heavier soils such as at Pomeroy, Pullman, or Hooper, Atrazine dosages of 3/4 to 1# per acre are effective. Extensive field trials with Atrazine were conducted at 13 locations in eastern Washington in 1962. The results of nine of these locations are summarized in Table 8.

Table 8. Average Yield of Wheat Using Two Rates of Atrazine in Nine Locations in 1962.

Location	Plot Yield in Bu/Acre			Wheat Variety
		Treatments		
	Control	1/2 lb.	1 lb.	
Pomeroy	47	58	65	Omar
Dayton	31	36	63	Burt
Eureka	63	54	63	Gaines
St. John	40	56	54	Omar
Hartline	40	47	49	Elgin
Horse Heavens	29	22	18	Burt
Ewan	43	43	86	Brevor
Ritzville	21	40	36	Omar
Connell	27	0	0	Turkey Red

Atrazine is still the most effective herbicide for post-emergence treatments. This material has a relatively long residual life in soils of low organic matter. Atrazine requires vigorous mechanical agitation in the spray tank for uniform application. Pump and nozzle screens should be 50 mesh or larger. Overlapping of the spray pattern will cause damage. Atrazine is not registered for selective use in wheat but efforts are being made to register the material.

Screening trials at Lind and Hooper in 1963 show favorable results for cheatgrass control using Avadex and Avadex B.W. The Avadex materials are pre-plant incorporated. A new Stauffer herbicide also looks promising as a pre-plant incorporated material. The screening trials also show some good cheatgrass activity using pre-emergence chemicals.

Chemical fallow studies at Pullman show some favorable results using 2,4-D, Amitrol, Amitrol-T, Dowpon, and Atrazine alone or in various combinations. However, residual problems with Dowpon and Atrazine may occur in light sandy soils. Several new materials for chemical fallow will be tested in Lind this fall.

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 35 years old. Plantings have been made at intervals since the original planting. The station planting is one of the best in the West for studying trees and shrubs adapted to dry land conditions.

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. Douglas fir and Blue spruce can be grown but require more care and grow much slower. 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. Transplanting evergreen stock has survived better than seedling stock. Although transplanted stock is more expensive, the superior survival compensates for the extra cost.

Table 9. 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 Scotch pine Ponderosa pine	Evergreen	12 ft.	27 ft.

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