UNITED STATES DEPARTMENT OF AGRICULTURE

BULLETIN No. 498

Contribution from the Bureau of Plant Industry
WM. A. TAYLOR, Chief

Washington, D. C. ▼ February 19, 1917

EXPERIMENTS WITH SPRING CEREALS AT THE EASTERN OREGON DRY-FARMING SUBSTATION MORO, OREG.

By

DAVID E. STEPHENS, Station Superintendent
Office of Cereal Investigations

CONTENTS

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By David E. Stephens, *Station Superintendent, Office of Cereal Investigations.*

CONTENTS.

INTRODUCTION.

The Eastern Oregon Dry-Farming Substation [1] was established at Moro, Oreg., in 1909. The land was purchased and the buildings (fig. 1) erected with funds contributed by Sherman County. The expense of maintenance is borne jointly by the Oregon Agricultural Experiment Station and the Bureau of Plant Industry.

A cooperative agreement between the Bureau of Plant Industry and the Oregon Agricultural Experiment Station specifies that "The objects of the cooperative investigations shall be (*a*) to improve the cereals of the Pacific coast region by introducing or producing better varieties than those now grown, especially with regard to drought resistance, yield, quality, earliness, etc.; (*b*) to determine the best methods of cultivation and crop rotation for grain production; and (*c*) to conduct such other experiments as may seem advisable for the accomplishment of the greatest possible good to the cereal interests of the State of Oregon." Full credit is given to the Oregon Agri-

[1] From the establishment of the Moro substation until November, 1911, Mr. H. J. C. Umberger was superintendent. In February, 1912, the writer was appointed superintendent.

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cultural Experiment Station and to Sherman County for their share in obtaining the cooperative results reported in this publication.

Some preliminary work was done in 1910, but most of the experiments were not started until 1911. The investigational work at Moro comprises tests of methods of production and improvement of cereals, including crop rotation and tillage. This bulletin deals only with the varietal tests of spring-sown cereals, including wheat, emmer, oats, barley, and grain sorghums.

DESCRIPTION OF THE STATION.

The Eastern Oregon Dry-Farming Substation is located in the southwestern part of the Columbia Basin,[1] near Moro, in Sherman County, Oreg. Eastern Oregon, as the term is used locally, refers to all that portion of the State east of the Cascade Mountains. Sherman County lies along the Columbia River, the northern border of the State. It is really about midway of the State from east to west. Moro is

FIG. 1.—General view of the station buildings at the Eastern Oregon Dry-Farming Substation, at Moro.

about 15 miles from the Columbia River, on a branch line of the Oregon-Washington Railroad & Navigation Co. A map of the State, on which the location of the substation is indicated, is shown in figure 2.

The elevation of the substation is approximately 2,000 feet. The soil and climatic conditions at Moro are typical of a large part of the Columbia Basin. It is believed, therefore, that the results obtained at the substation are applicable in a general way to most of the Columbia Basin, but especially to districts where the prevailing soil type is silt loam and where the annual average precipitation ranges from 9 to 12 inches.

The substation comprises 233 acres, about 200 of which are tillable. Like most of the Columbia Basin lands, the surface is very rolling, nearly every direction and inclination of slope being represented. On the experimental plats the slopes vary from nearly level

[1] For a general description of the Columbia Basin, see Hunter, Byron, Farm practice in the Columbia Basin uplands, U. S. Dept. Agr., Farmers' Bul. 294, 30 p., 1907.

land to a rise of 11 feet per 100. A contour map of the substation is shown in figure 3.

For the purpose of comparing the soil and climatic conditions at Moro with those of other localities, a brief description is given of the soil and climate at the substation.

SOIL.

The soil at the substation is the fine silt loam characteristic of a large portion of the Columbia Basin. It is classified by the Bureau of Soils as Yakima silt loam. It is derived largely from the decom-

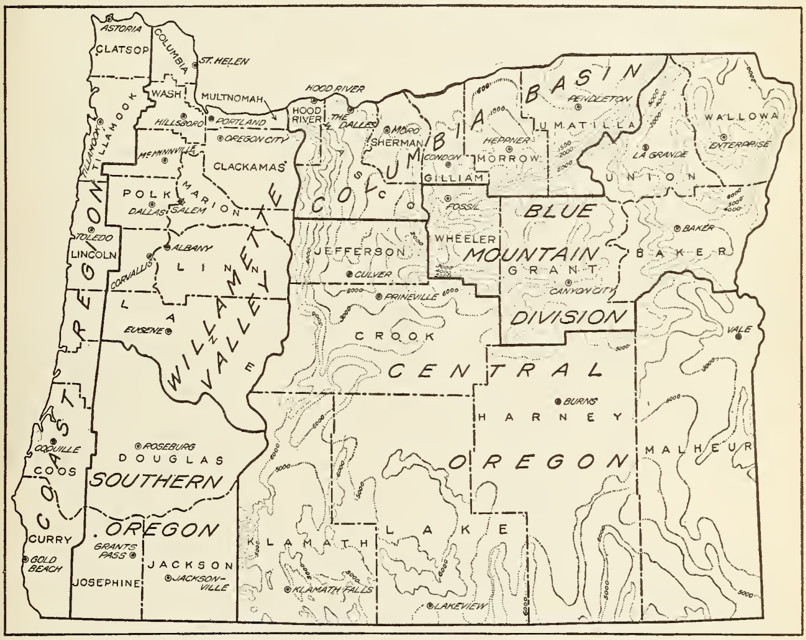

FIG. 2.—Map of Oregon, showing contour lines east of the Cascade Range and the location of the Eastern Oregon Dry-Farming Substation, at Moro.

position of the basaltic or lava rock by which it is underlain. Unlike some of the soils nearer the Columbia River, the percentage of sand is not high enough to cause trouble from soil shifting or blowing. The soil is easily worked and requires little cultivation to put it in good tilth, the only implements really necessary for making a good seed bed being a plow and a spike-tooth harrow. The disk harrow, however, is frequently used prior to plowing, and a bar weeder for surface cultivation of the summer fallow. According to Bradley,[1] the general composition of eastern Oregon soils, of which the substation soil is typical, is as shown in Table I.

[1] Bradley, C. E. Soils of Oregon. Oreg. Agr. Expt. Sta. Bul. 112, 48 p. 1912.

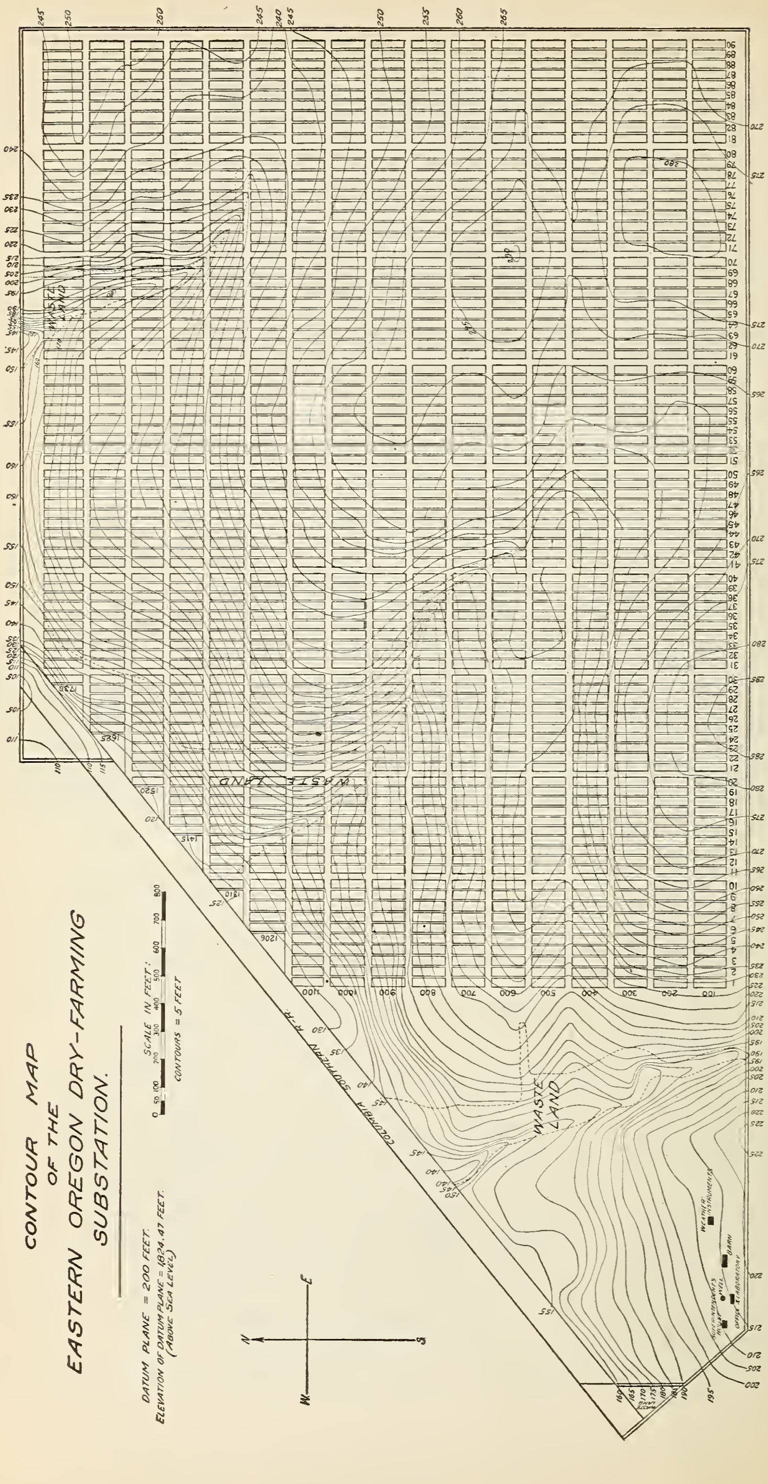

FIG. 3.—Contour map of the Eastern Oregon Dry-Farming Substation, Moro, Oreg., showing the method of dividing the farm into plats.

TABLE I.—*Composition of silt loam soil in the Columbia Basin.*

Constituents.	Total.	Soluble in 1.115 HCl.	Constituents.	Total.	Soluble in 1.115 HCl.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
Silica (SiO_2)	62.85	0.34	Iron and aluminum oxids (Fe_2O_3 and Al_2O_3)	8.47	8.37
Potash (K_2O)	1.63	.74	Phosphoric acid (P_2O_5)	.30	.21
Lime (CaO)	4.52	3.05	Nitrogen (N)	.11	
Magnesia (MgO)	1.94	1.66	Volatile	.37	
Manganese oxid (Mn_3O_4)	.04				

From analyses of surface soil obtained from both virgin and cropped areas Bradley concludes that "while the percentage of nitrogen in these soils has remained practically constant under continual cropping for, in extreme cases, 25 years, there has been a marked decrease in the carbon or organic content." Probably on account of this deficiency in humus the surface soil at the substation is inclined to run together or pack in the spring from the effects of winter precipitation.

The soil is remarkably uniform in texture, absorbs water readily, and has a high moisture-holding capacity. At the substation the depth of the soil to the rock formation underneath varies from 1 to 9 feet, the deeper soil being on the higher elevations and on the northward slopes. Where the ground slopes toward the west or southwest, the soil usually is shallow and therefore less suited to cereal production, because of its inability to store sufficient moisture to mature crops. Most of the farm had been cropped to grain for about 25 years prior to the establishment of the substation.

CLIMATIC CONDITIONS.

Careful records of climatological phenomena have been kept since January, 1910, in cooperation with the Biophysical Laboratory of the Bureau of Plant Industry. The weather-observing equipment consists of standard snow and rain gauges, maximum and minimum thermometers, self-recording thermographs, an evaporation tank, an anemometer, and a psychrometer.

PRECIPITATION.

In no other place in the world is cereal production conducted on such an extensive scale with so little precipitation as in the Columbia Basin. As Table II shows, the lowest annual precipitation in the vicinity of Moro during the past 10 years has been 7.68 inches. The precipitation for the years from 1905 to 1909, inclusive, was recorded at Grass Valley, which is about 10 miles south of Moro, while that for the years 1910 to 1915, inclusive, was recorded at the substation. The average annual precipitation for the 11-year period from 1905 to 1915 is 11.35 inches. The highest annual precipitation since records have been kept at the substation is 14.89 inches.

TABLE II.—*Monthly and annual precipitation at Grass Valley and Moro, Oreg., showing the average, maximum, and minimum for each month, from 1905 to 1915, inclusive.*

[Precipitation data (in inches): Previous to December, 1909, from the Oregon-Washington Railroad & Navigation Co., Grass Valley, Oreg.; since December, 1909, from the substation records. T=trace.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1905	0.76	0.20	0.05	0.03	1.70	1.30	0.36	T	0.75	1.36	0.85	1.35	8.71
1906	1.00	.85	1.65	.10	1.05	1.85	T	.34	.35	T	2.59	2.22	12.00
1907	2.65	.48	1.60	1.06	.90	.89	.30	.71	.50	.20	1.46	2.68	13.43
1908	.55	..02	.68	.11	1.41	.37	.22	.34	.12	1.11	1.12	1.63	7.68
1909	2.56	1.03	.68	.10	.49	.99	.10	.02	.45	.87	3.34	1.14	11.77
1910	.95	1.47	.63	.66	1.25	.89	T	.00	.20	.70	2.76	.88	10.39
1911	1.18	.46	.25	.35	1.05	.64	.00	T	4.03	.33	.30	.61	9.20
1912	3.58	1.36	.69	.78	1.33	.42	.02	.74	.21	.78	1.30	2.12	13.33
1913	1.33	.23	.76	.58	2.27	1.39	.06	.05	.49	1.87	1.45	1.69	12.17
1914	2.20	1.16	.11	2.06	.76	.66	.08	T	1.05	1.48	.88	.88	11.32
1915	1.75	2.31	1.27	.65	2.06	.36	.57	.05	1.14	.23	2.89	1.61	14.89
Average	1.68	.87	.76	.59	1.30	.89	.16	.20	.84	.81	1.72	1.53	11.35
Maximum	3.58	2.31	1.65	2.06	2.27	1.85	.57	.74	4.03	1.87	3.34	2.58	14.86
Minimum	.55	.02	.05	.03	.49	.37	.00	.00	.12	T	.30	.61	7.68

The distribution of the precipitation usually is favorable for growing cereals, nearly all of the rain falling during the months from

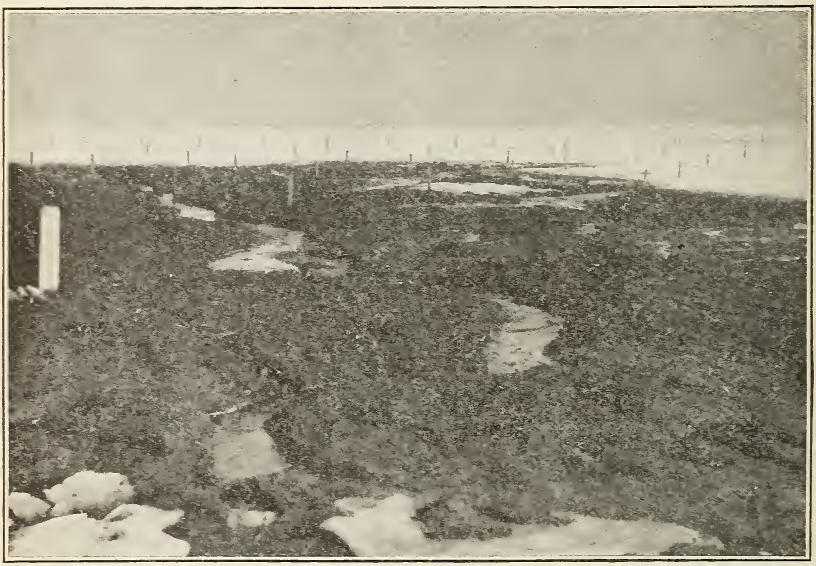

FIG. 4.—Experimental plats at the Moro substation in the spring of 1916, showing the run-off during the melting of a heavy covering of snow.

September to June. July and August are practically rainless. In some years there is considerable run-off in the winter or early spring (fig. 4). Soil samples taken to a depth of 6 feet on 20 plats in May, 1913, had an average of only 1 per cent more moisture than samples taken on the same plats in November, 1912, though the precipitation during the interval measured 5.5 inches. From September 1, 1914, to February 28, 1915, the precipitation was 8.35 inches, but this penetrated stubble ground to a depth of less than 2 feet. The rains which occur during the late spring, summer, and autumn months are of such a nature that practically all of the water is absorbed by the soil, but much of the winter precipitation is frequently lost as run-off. As is shown in Table II, the wettest months are November, December, and January. Much of the precipitation during these months is usually in the form of snow.

The 11-year average precipitation by months is shown graphically in figure 5.

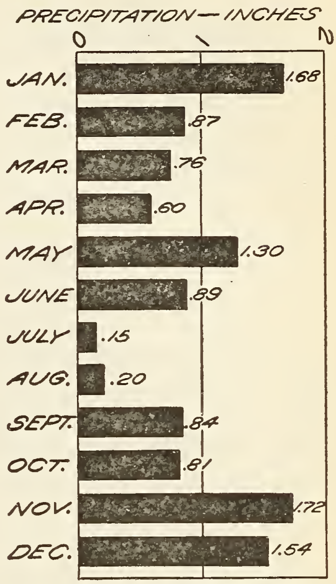

FIG. 5.—Diagram showing the average monthly precipitation in inches at Moro, Oreg., during the 11 years from 1905 to 1915.

The precipitation available for growing cereals during any particular season in this section is largely that which falls from September 1 to August 31. In comparing crop production with precipitation data, therefore, records for calendar years are not so valuable as those for crop years ending August 31. The precipitation which falls during the growing season is also an important factor in influencing crop yields. The average seasonal precipitation for small grains (March to July, inclusive), as shown in Table III, is 3.83 inches.

Table III gives precipitation records for each of the five crop years for which results are reported in this bulletin, 1911 to 1915, inclusive, and also the precipitation for the growing season in each of those years.

TABLE III.—*Precipitation at Moro, Oreg., in crop years (ending Aug. 31) and in the growing season (March to July, inclusive), for five years, 1911 to 1915, inclusive.*

Period.	Inches.	Period.	Inches.
Annual:		Seasonal:	
Sept. 1, 1910, to Aug. 31, 1911	8.47	Mar. 1 to July 31, 1911	2.29
Sept. 1, 1911, to Aug. 31, 1912	14.19	Mar. 1 to July 31, 1912	3.24
Sept. 1, 1912, to Aug. 31, 1913	11.08	Mar. 1 to July 31, 1913	5.06
Sept. 1, 1913, to Aug. 31, 1914	12.53	Mar. 1 to July 31, 1914	3.67
Sept. 1, 1914, to Aug. 31, 1915	13.31	Mar. 1 to July 31, 1915	4.91
Average	11.92	Average	3.83

It will be observed that the crop year of 1912, from the standpoint of precipitation, was the most favorable for crop production of any of the five years for which data are here given. The crop year of 1911 was very unfavorable, the total precipitation being only 8.47 inches, of which only 2.29 inches fell during the growing season. The average for the five years ending August 31 is 0.57 inch more than the 11-year average, and the average for the growing season in the five years is 0.13 inch more than the 11-year average for the same months.

EVAPORATION.

Records of evaporation from a free water surface have been kept during the seven months, April to October, inclusive, in the years 1911 to 1915, inclusive. The method used is the same as at other stations cooperating with the Biophysical Laboratory of the Bureau of Plant Industry.[1] The evaporation tank at Moro is 2 feet deep and 6 feet in diameter. Table IV gives the monthly evaporation, April to October, inclusive, in the years 1911 to 1914, inclusive.

TABLE IV.—*Evaporation, in inches, from a free water surface at Moro, Oreg., in the seven months, April to October, inclusive, for five years, 1911 to 1915, inclusive.*

Month.	1911	1912	1913	1914	1915	Average.
April	5.92	4.51	4.09	4.02	5.13	4.73
May	6.13	6.75	6.24	7.43	5.90	6.50
June	9.61	7.75	7.36	8.29	8.45	8.29
July	11.57	7.89	7.90	11.43	9.05	9.57
August	9.28	6.72	7.82	9.64	9.59	8.61
September	4.16	4.50	4.82	4.40	5.30	4.64
October	2.34	2.60	3.52	2.20	2.98	2.73
Total	49.01	40.72	41.75	47.41	46.40	45.07

The highest evaporation occurred in 1911, when the evaporation for the seven months was approximately five times greater than the total precipitation for that year. The lowest evaporation was in 1912, when the ratio of the evaporation for the seven months to the total precipitation for the year was about 3 to 1. During the 6-month period from April to September, inclusive, the average evaporation at the substation in the years from 1911 to 1915, inclusive, was 42.34 inches. This is greater than the evaporation reported by Briggs and Belz[1] during a 6-month period at any station north of the fortieth parallel of latitude (the northern boundary of Kansas).

Table V shows the evaporation and precipitation and the winter-wheat yields at the Moro substation and two other representative dry-farming stations, one in the Great Basin at Nephi, Utah, at an elevation of nearly 6,000 feet, and one in the northern Great Plains at Moccasin, Mont., at an elevation of 4,300 feet. The wheat yields reported in Table V were produced under the same method, alternating wheat with summer fallow, at all the stations. Investigations similar to those conducted at Moro are being carried on at Nephi and at Moccasin. The precipitation and evaporation data are taken from the records of the Biophysical Laboratory and the wheat yields from the records of the Office of Cereal Investigations.

[1] Briggs, L. J., and Belz, J. O. Dry farming in relation to rainfall and evaporation. U. S. Dept. Agr., Bur. Plant Indus. Bul. 188, p. 16–20. 1910.

Data are available for the years 1909 to 1915 at Moccasin, for the years 1908 to 1915 at Nephi, and for the years 1911 to 1915 at Moro.

TABLE V.—*Precipitation and evaporation data and yields of winter and spring wheat at Moccasin, Mont., Nephi, Utah, and Moro, Oreg., in the years indicated.*

Character of data.	Moccasin, 1909 to 1915.	Nephi, 1908 to 1915.	Moro, 1911 to 1915.
Average precipitation:			
Annual .... inches..	16.66	12.78	12.18
Seasonal (April to August, inclusive) .... do....	9.06	5.15	3.39
Average evaporation:			
Seasonal (April to August, inclusive) .... do....	27.96	38.71	37.70
Ratio of annual precipitation to seasonal evaporation	1:1.68	1:3	1: 3.2
Ratio of seasonal precipitation to seasonal evaporation	1:3.1	1:7.5	1:11.2
Average yield of best winter wheat .... bushels..	35.7	25	[a] 23
Average yield of best spring wheat .... do....	27.6	10	22.1

[a] Average yield of 10 plats of Turkey wheat in tillage experiments.

The average annual precipitation and the average seasonal precipitation are greater at Moccasin and at Nephi than at Moro. The average evaporation from April to August, inclusive, is 1.01 inches greater at Nephi and 9.74 inches less at Moccasin than at Moro. The ratio of annual precipitation to seasonal evaporation is slightly greater at Moro than at Nephi, but there is a wide difference between the ratios of seasonal precipitation and seasonal evaporation at Moro and the other two stations.

TEMPERATURE.

Table VI gives the highest, lowest, and mean temperatures for each month of the years 1911 to 1915, inclusive, and also the average of the means, the average of the maxima, and the average of the minima by months for the 5-year period.

TABLE VI.—*Mean, maximum, and minimum temperatures at Moro, Oreg., by months, for five years, 1911 to 1915, inclusive.*

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Mean:												
1911	30.3	30.6	43.5	46.2	51.0	60.6	70.0	66.0	54.8	46.9	38.0	34.0
1912	29.3	36.8	37.9	45.7	54.6	61.4	66.0	62.5	55.0	44.9	40.7	33.0
1913	29.5	28.8	38.2	46.6	54.6	60.4	67.9	68.0	57.6	47.3	40.7	28.0
1914	36.5	33.3	43.8	47.6	56.2	59.5	70.5	69.1	55.5	49.5	38.1	22.8
1915	29.0	36.0	45.0	50.8	53.0	60.0	64.8	71.3	57.3	50.6	38.2	32.8
Average	30.5	33.1	41.7	46.6	53.9	59.6	67.8	67.4	56.0	47.8	39.1	28.6
Maximum:												
1911	55	46	77	74	86	89	103	89	87	75	61	53
1912	51	52	65	68	86	96	98	97	85	69	61	54
1913	53	58	57	75	83	89	101	99	88	74	57	47
1914	51	38	69	72	88	91	99	100	83	69	59	46
1915	41	52	70	75	78	93	96	100	86	73	54	53
Average	50.2	49.2	67.6	72.8	84.2	91.6	99.4	97.0	85.8	72.0	58.4	50.6
Minimum:												
1911	5	9	11	22	30	32	44	42	34	32	4	5
1912	−6	26	20	28	33	37	43	38	31	25	23	19
1913	5	7	9	28	36	37	41	41	33	28	29	10
1914	28	28	27	29	32	34	42	43	29	32	19	−3
1915	10	23	30	32	34	40	40	46	36	33	25	11
Average	8.4	18.6	19.4	27.8	33.0	36.0	42.0	42.0	32.6	30.0	20.0	8.2

Table VII shows the dates of the latest spring frosts and the earliest autumn frosts, together with the minimum temperature recorded for those dates in the years 1911 to 1915, inclusive. It will be observed from this table that during the five years no frost occurred in June, July, or August. None of the frosts recorded on the dates mentioned in Table VII did any damage to cereals. The longest frost-free period was in 1915, 211 days, and the shortest frost-free period in 1914, 108 days. The average frost-free period for the five years is 155.8 days.

TABLE VII.—*Data relating to killing frosts at the Moro substation in the years 1911 to 1915, inclusive.*

Year.	Last in spring.		First in autumn.		Frost-free period.
	Date.	Temperature.	Date.	Temperature.	
		° *F.*		° *F.*	*Days.*
1911	May 8	32	Oct. 17	32	162
1912	Apr. 29	31	Sept. 3	31	127
1913	Apr. 27	31	Oct. 15	32	171
1914	May 27	32	Sept. 12	32	108
1915	Apr. 8	32	Nov. 5	30	211
Average	May 2		Oct. 5		155.8

WIND.

The prevailing winds at Moro are from the west, southwest, and northeast. Southwest or west winds usually are accompanied by cool or moderately warm weather in the summer and mild weather in winter, while east or northeast winds are nearly always accompanied by high temperatures in summer and low temperatures in winter. Though wind velocities are never exceedingly high, the wind movement is quite constant from about March 1 to August 31. The number of miles of wind during any 24-hour period rarely exceeds 350, 490 miles being the highest number recorded at the substation for any one day of 24 hours during the years 1911 to 1915, inclusive.

Table VIII gives the average wind velocity in miles per hour for each month of the years 1911 to 1915, inclusive.

TABLE VIII.—*Average wind velocity (in miles per hour), by months, at the Moro substation in the years 1911 to 1915, inclusive.*

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Average.
1911	5.3	5.4	6.3	9.6	9.2	11.8	9.4	9.2	7.2	4.8	6.7	5.5	7.5
1912	3.7	4.9	6.1	8.4	7.8	5.9	5.6	5.3	2.8	2.0	2.9	4.1	4.9
1913	2.4	2.8	5.9	7.3	8.3	6.9	5.9	6.3	3.8	5.0	4.0	2.7	5.1
1914	5.4	5.0	5.6	6.5	7.1	8.8	8.8	7.5	6.0	4.0	4.5	3.9	6.1
1915	3.2	4.0	4.7	6.7	5.4	8.2	8.1	7.5	7.0	6.1	4.3	5.4	5.9
Average	4.0	4.4	5.7	7.7	7.5	8.2	7.6	7.2	5.2	4.4	4.5	4.5	5.9

Table VIII shows that June is the windiest month, though there is little difference in the monthly averages for any month from April to August, inclusive. The highest average wind velocity for any year in the 5-year period was 7.5 miles per hour, in 1911. The year 1911 was also the one with the least precipitation and the greatest evaporation.

EXPERIMENTAL METHODS.

The experimental work with cereals is conducted for the following purposes: (1) To ascertain what grain varieties are best adapted to the drier districts of the Columbia Basin, (2) to improve the best adapted varieties by selective breeding, (3) to determine what crop-rotation systems will prove most profitable in connection with grain raising, and (4) to find out the most economical and profitable methods of soil tillage for cereal production in this section.

The work with spring grains during the first few years was along two lines, the testing of varieties and the improvement of varieties by pure-line selections. No work in hybridization has been attempted. A large number of pure lines have been developed, some of which give promise of being of considerable value. In this bulletin only the results of the varietal experiments will be given.

In the testing of varieties, field plats and nursery rows are used, the unit of comparison being a tenth-acre or twentieth-acre in the plat experiments and 1-rod or 2-rod replicated rows in the nursery experiments. Eight-rod rows and eightieth-acre plats also have been used in the nursery. While a rather careful study is made of the varieties in the nursery and in the plat experiments and numerous notes taken on the habits of the plants, the value of a variety has been judged largely by its yield of grain.

DIMENSIONS OF PLATS.

As shown in figure 3, the substation farm is laid out in series of tenth-acre plats 8 rods long and 2 rods wide. The series are separated by roads 16½ feet wide and are divided into blocks of 10 plats each by roads of the same width. Alleys 4½ feet wide separate the individual plats within these blocks.

When twentieth-acre plats were used, each tenth-acre plat was divided in half by an alley 22 inches wide. The twentieth-acre plats discussed in this bulletin actually contain only 2,062.5 square feet, or 115.5 square feet less than one-twentieth of an acre. In computing yields per acre, however, no account has been taken of this shortage. Acre yields computed from the yields of small plats are likely to be slightly exaggerated on account of the increased proportion of margin.

The plan first adopted at the substation for the varietal experiments was to grow a single tenth of an acre of each variety, with every fifth plat sown uniformly to one variety and regarded as a check. The two methods described in previous publications [1] have been used to determine relative or computed yields, but neither has proved entirely satisfactory. The variation in check-plat yields of spring grains usually has not been great. Occasionally, however, wide variations occur in the yields of check plats which can not be explained in any satisfactory manner.

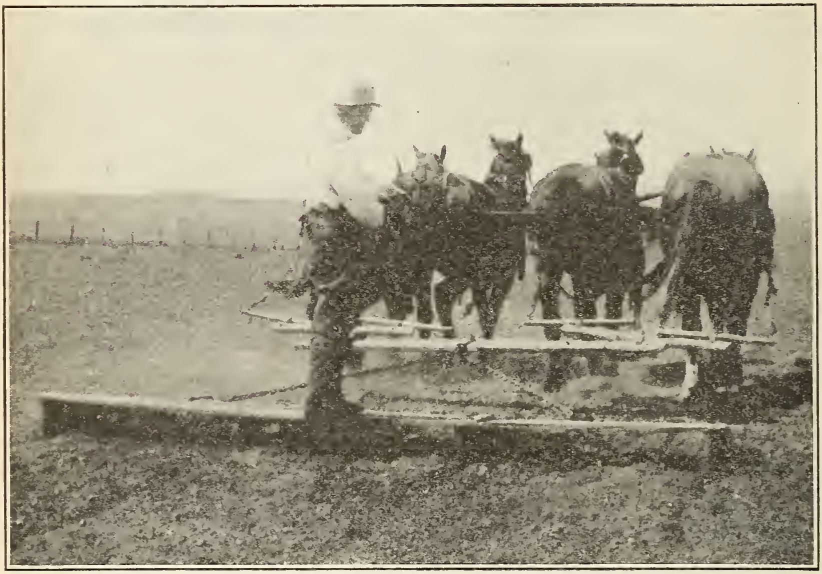

FIG. 6.—A bar weeder, or "slicker," in operation at the Eastern Oregon Dry-Farming Substation.

Beginning with 1913, each variety of spring grain in a varietal test has been sown in duplicate twentieth-acre plats. The plats in the two series are arranged as follows:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
11	12	13	14	15	16	17	18	19	20	1	2	3	4	5	6	7	8	9	10

All yields in this bulletin are reported in bushels per acre, based on the actual yields of a single tenth-acre or the average actual yields of two twentieth-acre plats.

TREATMENT OF PLATS.

The general practice in growing cereals in the Columbia Basin is to alternate a grain crop with bare fallow, commonly called summer

[1] Cardon, P. V. Cereal investigations at the Nephi substation. U. S. Dept. Agr. Bul. 30, p. 12, 33. 1913. Clark, J. Allen. Cereal experiments at Dickinson, N. Dak. U. S. Dept. Agr. Bul. 33, p. 11, 12. 1914.

fallow. This alternation has been followed almost without exception in the varietal experiments at the substation. The station crops have been produced by the methods in general use by the farmers in this section, and the yields reported are about those which ordinarily may be expected. The land is plowed 7 to 8 inches deep in April, an early spring disking usually being given prior to plowing. Immediately after plowing, the ground is harrowed once with a spike-tooth harrow, and another harrowing is given when weed growth starts. Later in the season, in order to eradicate weeds, the plats are cultivated with a weeder, locally known as a bar weeder. If necessary, this implement is used again later, the aim being to keep the fallow ground free from weeds. In order to accomplish

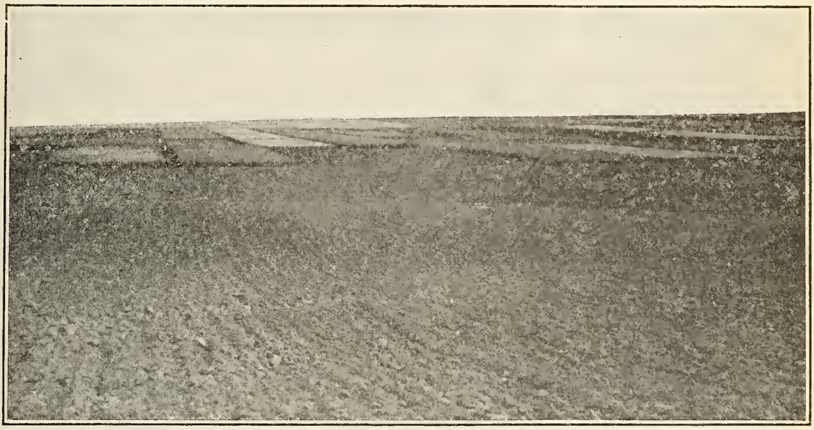

Fig. 7.—Plats of the rotation experiments at the Moro substation, showing summer-fallow land in almost ideal condition in the foreground and small grains and corn in the background. Photographed in July, 1914.

this it sometimes has been necessary to cultivate so frequently that the soil has been too finely pulverized. The soil at the substation, if cultivated too much, may become so compacted after the winter snows and rains that much of the precipitation of winter and early spring is lost as run-off instead of being absorbed. Figure 6 shows the bar weeder in operation, and figure 7 shows the condition in which the fallow is usually kept during the summer months.

Just prior to seeding spring grains, the ground is double disked and then harrowed once. Seeding is done with a disk drill, and no cultivation is given after seeding.

The land in the vicinity of the substation is infested with several weeds that have been found difficult to control in the experimental plats. The two most troublesome in spring grains are the Russian thistle (*Salsola pestifer*) and tumbleweed (*Amaranthus graecizans*). Where good stands of grain are obtained the latter weed is rarely found, but the Russian thistle sometimes has been troublesome, especially in early-sown spring grain and in grain with thin stands.

In the experimental plats the weeds have been destroyed by hand hoeing.

All varieties are carefully rogued to free them from accidental mixtures. They are cut with a binder, shocked, and then thrashed several weeks later with a small separator run by a gasoline engine. The grain from each plat is weighed after thrashing and the bushel weight determined. No straw weights have been recorded. The rows and small plats are thrashed with a small separator designed for that purpose.

CEREAL EXPERIMENTS.

SPRING WHEAT.

From the standpoint of total production in bushels, spring wheat is not as important in the Columbia Basin as winter wheat. Con-

FIG. 8.—Varietal plats of spring grain at the Moro substation, showing summer-fallow land in the foreground. Photographed July, 1914.

siderable spring wheat is grown, however, on account of the fact that dry weather frequently prevails until so late in the autumn that winter wheat can not be sown with safety. Winter wheat is better adapted to the present summer-fallow system of grain production in the Columbia Basin, because it permits a better distribution of farm labor. Winter wheat also usually gives yields somewhat higher than those of spring wheat.

Many wheat varieties, like Pacific Bluestem and Little Club, are sown in the Columbia Basin in either the autumn or spring, except on the higher elevations.

VARIETAL EXPERIMENTS.

Seventy-seven varieties of spring wheats have been tried at the substation. Some of these, which did not appear to be at all adapted, were discarded after a 2-year trial. New varieties have been added from time to time, and 5-year average yields have been obtained for only seven varieties. Table IX gives the annual acre yields of all the spring-wheat varieties which have been tested. In this table the varieties are arranged in alphabetical order, without regard to the period during which they were grown, their rank in yield, or other relationships. Figure 8 shows a portion of the plats in the varietal experiments with spring grain in 1914.

TABLE IX.—*Spring-wheat varieties tested at the Moro substation, showing the yields obtained in each year the variety was grown during the five years, 1911 to 1915, inclusive.*

Variety.	C. I. No.	Division.	Origin.	Yield per acre (bushels).[a]				
				1911	1912	1913	1914	1915
Abd-el-Kader	2075	Durum	Tunis	11.1	15.5			
Alaska		Poulard	Southern Europe			13.6	15.0	[b] 9.4
Aulieata	2407-1	Common	Turkestan	[b] 1.5	[c] 9.4	[c] 9.4		
Do	2407-2	do	do	[b] 8.3	[c] 31.2	23.0	22.9	20.2
Barbilla	2944	do	Teneriffe	[c] 8.4	[d] 12.6			
Beseler Squarehead	2681	do	Germany	[c] 7.7	[d] 11.0			
Black Persian	2823	do	Argentina	([e])	([e])	[b] 8.9	[b] 3.1	[b] 6.6
Blé Noir	2511-2	Durum	Abyssinia	3.5	7.5	18.0	18.3	23.6
Bluestem. (See Pacific Bluestem.)								
Bobs	2826-1	Common	Australia	[b] 13.8	[c] 18.3	[c] 15.6	24.7	25.4
Bola Blanca	2921-1	Club	Mexico	[b] 4.2	([e])	[c] 12.7	[b] 14.6	[d] 16.5
Chul	2227	Common	Turkestan	11.2	12.9			
Do	2227-1	do	do	[b] 13.6	[b] 17.8	[c] 14.0	21.5	20.2
Dale Gloria	4155	Club	Oregon (?)	3.8	8.6	18.3	18.0	
Early Baart	1697	Common	Australia	14.5	19.0	25.0	26.0	26.6
Elephant	2824-1	do	do	([e])	[b] 12.0	[c] 10.1	[b] 3.1	[b] 13.6
Erivan	2397-1	do	Russia	([e])	([e])	([e])	[b] 12.4	[c] 10.2
Fishhead	1732	do	China	[c] 9.8	[d] 12.8			
Galgalos	2398	do	Russia	7.8	12.8			
Do	2398-1	do	do	([e])	[c] 14.2	[c] 8.0	([e])	[b] 14.6
Ghirka Spring	1517	do	do			19.6	16.2	26.1
Glyndon (Minn. No. 163).	2873	do	Minnesota	9.1	12.3	16.6		
Heine Squarehead	2669	do	Germany	[c] 10.1	[d] 20.0	21.6	22.5	23.6
Hurma	2124-3	Durum	Arabia	[c] 12.9	[d] 7.0			
Hybrid No. 63	4157	Club	Washington		15.5	20.6	15.3	
Hybrid No. 108	5025	do	do	[c] 6.7	8.6	[c] 13.6	[d] 3.3	
Japanese	1787	Common	Japan	12.1	14.3			
Kahla	2088-4	Durum	Algeria	[b] 11.4	[c] 7.5	([e])	[b] 6.7	[b] 8.0
Karun	2200-1	Common	Persia	[c] 11.0	[d] 15.6	24.0	25.4	29.4
Khojend	2402-1	do	Turkestan	([e])	[b] 15.7	[c] 12.5	[d] 13.3	[d] 16.8
Kisil	2405	do	do	[c] 8.2	([e])	([e])	[b] 9.3	
Koola	2203-2	do	Arabia	[c] 14.2	[d] 12.0	25.8	24.2	33.2
Kubanka	1440	Durum	Russia	11.0	16.2	13.6	15.0	
Do	1516	do	do			16.0	21.5	18.0
Do	2246	do	do	7.0	12.0			
Kurd	2126-2	do	Arabia	[c] 9.6	[d] 10.0	([e])	[b] 4.2	[b] 14.6
Little Club (Wash. No. 349).	4066	Club	Washington	13.1	22.6	19.6	19.2	26.0
Mahmoudi	2099	Durum	Algeria	8.8	6.6			
Do	2099-1	do	do	[c] 10.5	[c] 9.8			
Marouani	1593	do	do	11.3	15.8			
Do	2235	do	do	8.3	14.5			
Marquis	4158	Common	Canada			22.1	22.5	23.1
Pacific Bluestem	4067	do	Australia	11.7	20.2	19.4	20.9	24.0
Pelissier	1584-1	Durum	Algeria	([e])	[b] 10.9	([e])	[c] 6.2	[b] 16.6
Do	2086	do	do	[b] 2.6	[c] 9.0			
Rebeiro	2794	Common	Portugal	[c] 4.8	[d] 8.6			
Richi	2089	Durum	Algeria	9.3	18.5			
Do	2089-1	do	do	[b] 10.4	[c] 18.0			
Rieti	2793	Common	Portugal	[c] 8.3	[d] 14.0	21.3	19.0	24.9
Rysting Fife	3022-1	do	Minnesota	([e])	[b] 18.7	[c] 12.7	[d] 5.0	
Saragolla	2228	Durum	Italy	[c] 8.2	[d] 12.7			
Saumur	2346-1	Common	France	([e])	[b] 23.9	[c] 16.0	23.0	22.7
Sonora	3036-2	do	Mexico (?)	[b] 8.2	[b] 34.4	15.5	20.5	24.7
Do	4074	do	do		4.6	15.3	16.3	
Talimka	2495	do	Turkestan	[c] 7.0	[d] 14.6	27.5	23.0	25.9
Urtoba	2670	do	Germany	([e])	[b] 18.7	[c] 12.5	[d] 8.0	[b] 16.0
Velvet Don	2247	Durum	Russia	9.1	12.1			
Do	2247-1	do	do	([e])	[b] 15.6	[b] 14.6	[c] 8.4	

[a] Acre yields are based on yields from single tenth-acre or duplicate twentieth-acre plats unless otherwise stated.
[b] Grown in rod rows, usually unreplicated.
[c] Grown in 2-rod rows replicated 2 to 4 times.
[d] Grown in single fortieth-acre plats.
[e] Grown in head rows, yield not recorded.

TABLE IX.—*Spring-wheat varieties tested at the Moro substation, showing the yields obtained in each year the variety was grown during the five years, 1911 to 1915, inclusive*—Contd.

Variety.	C. I. No.	Division.	Origin.	Yield per acre (bushels).[a] 1911	1912	1913	1914	1915
Yantagbay	2404–1	Common	Russia	9.6	19.0	21.3	19.2	25.2
Yellow Gharnovka	2096	Durum	do	7.8	16.6	......	......	......
Zacatecas	2799–2	Common	Mexico	[b] 4.8	[b] 15.6	19.6	21.0	25.2
Unnamed	2033	do	Hungary	[b] 7.8	[c] 13.3	......	[d] 9.3	[b] 9.4
Do	2500–1	Durum	Algeria	[b] 10.6	[c] 12.6	......	......	......
Do	2545	do	do	[b] 9.7	[c] 9.3	......	......	......
Do	2547–2	do	Tunis	7.3	12.8	17.1	([e])	[d] 14.6
Do	2580	Common	Germany	[b] 6.6	[c] 9.8	......	......	......
Do	2603	do	Holland	[b] 8.7	[c] 14.3	([e])	[d] 7.2	([e])
Do	2607–1	Durum	Rumania	[d] 8.3	[b] 14.3	([e])	[d] 2.1	[d] 8.4
Do	2609–1	do	do	[d] 11.4	[b] 17.5	([e])	[d] 5.2	......
Do	2702	Common	Italy	[b] 6.2	[c] 6.6	......	......	......
Do	2705	do	do	[b] 8.8	[c] 9.3	......	......	......
Do	2796	Durum	Mexico	([e])	[c] 15.4	......	......	......
Do	2798	Poulard	do	[b] 4.8	[c] 6.0	......	......	......
Do	2941	Durum	Texas (?)	([e])	[b] 19.3	[b] 10.3	[c] 7.3	[c] 14.9
Do	3035–2	Club	Mexico	[d] 12.5	[b] 25.0	[b] 9.0	......	......
Do	4715	Common	China	([e])	([e])	[d] 12.5	Failure.	
Do	4716	do	do	([e])	([e])	[d] 15.2	[d] 10.4	[c] 12.0

[a] Acre yields are based on yields from single tenth-acre or duplicate twentieth-acre plats unless otherwise stated.
[b] Grown in 2-rod rows replicated 2 to 4 times.
[c] Grown in single fortieth-acre plats.
[d] Grown in rod rows, usually unreplicated.
[e] Grown in head rows, yield not recorded.

As the leading variety of spring wheat in the Columbia Basin is the Pacific Bluestem, this variety has always been grown on check plats. Table X presents a list of the spring-wheat varieties that have been grown three or more years, with yields expressed in percentages of the yield of the Bluestem variety. Where the varieties have been tested on areas smaller than one-twentieth of an acre, the average yield of the two highest yielding check plats or rows of the Pacific Bluestem was used as a basis of comparison. Where the test was on areas of one-twentieth acre or larger, the average yield of all Bluestem check plats was used. In all cases where the smaller areas were used, the Bluestem variety was sown in every fifth plat or row. It will be noted that certain varieties, like Koola, Karun, Early Baart, and Talimka, have given consistently higher yields than the Pacific Bluestem when grown in rows and in plats.

TABLE X.—*Yields of spring-wheat varieties grown at the Moro substation during three or more years, expressed in percentages of the average yield of the Pacific Bluestem variety grown in check plats and check rows.*

Variety.	C. I. No.	Yields (percentage of the yield of Pacific Bluestem). 1911	1912	1913	1914	1915	Average.
Aulieata	2407–2	......	[a] 200	119	109	85	128
Bluestem. (See Pacific Bluestem.)							
Blé Noir	2511	30	37	93	90	98	70
Bobs	2826–1	......	[a] 116	[a] 110	118	106	112
Bola Blanca	2921–1	......	......	[a] 89	[b] 157	[c] 165	137
Chul	2227–1	......	127	[a] 99	103	85	101
Dale Gloria	4155	33	43	94	87	......	64
Early Baart	1697	124	94	129	124	111	116
Elephant	2824–1	......	[b] 82	[a] 71	[b] 40	[b] 52	61
Galgalos	2398	70	61	[a] 57	......	......	63
Do	2398–1	......	[a] 90	[a] 56	......	[b] 54	67
Ghirka Spring	1517	......	......	101	77	109	96
Glyndon (Minn. No. 163)	2873	80	63	85	......	......	76

[a] Grown in 2-rod rows replicated 2 to 4 times.
[b] Grown in rod rows, usually unreplicated.
[c] Grown in single fortieth-acre plats.

TABLE X.—*Yields of spring-wheat varieties grown at the Moro substation during three or more years, expressed in percentages of the average yield of the Pacific Bluestem variety grown in check plats and check rows*—Continued.

Variety.	C. I. No.	Yields (percentage of the yield of Pacific Bluestem).					
		1911	1912	1913	1914	1915	Average.
Heine Squarehead	2669	[a] 150	[b] 146	111	108	98	123
Hybrid No. 63	4157	....	76	106	71	....	84
Hybrid No. 108	5025	[a] 100	42	[a] 96	[b] 35	....	68
Kahla	2088–4	....	[a] 50	....	[c] 72	[c] 30	51
Karun	2200–1	[a] 164	[b] 114	124	121	122	129
Khojend	2402–1	....	[c] 112	[a] 88	[b] 133	[b] 168	125
Koola	2203–2	[a] 212	[b] 88	133	116	134	136
Kubanka	1440,1516	94	80	84	103	75	87
Kurd	2126–2	[a] 143	[b] 73	....	[c] 50	[c] 56	80
Little Club (Wash. No. 349)	4066	114	108	100	91	108	104
Marquis	4158	....	....	114	108	96	106
Pacific Bluestem	4067	100	100	100	100	100	100
Pelissier	1584–1	....	[c] 77	....	[c] 73	[c] 64	71
Rieti	2793	[a] 124	[b] 102	109	93	104	106
Rysting Fife	3022–1	....	[c] 133	[a] 90	[b] 52	....	91
Saumur	2346–1.	....	[c] 170	[a] 113	110	95	122
Sonora	3036–2	....	[c] 242	80	98	103	131
Do	4074	....	23	79	80	....	66
Talimka	2495	[a] 104	[b] 106	141	110	108	114
Urtoba	2670	....	[c] 133	[a] 89	[b] 84	[c] 62	92
Velvet Don	2247–1	....	[c] 111	[c] 88	[a] 98	....	99
Yantagbay	2404–1	84	94	109	93	105	97
Zacatecas	2799–2	[a] 71	[b] 77	101	100	105	91
Unnamed	2033	[a] 117	[a] 97	....	[c] 108	[a] 74	91
Do	2547–2	64	63	88	....	[c] 56	68
Do	2603	[a] 128	[b] 104	....	[c] 83	....	105
Do	2607	....	[a] 90	....	[c] 23	[c] 32	48
Do	2941	....	[a] 122	[a] 80	[b] 77	[b] 149	107
Do	4716	....	....	[c] 90	[c] 112	[b] 120	107

[a] Grown in 2-rod rows replicated 2 to 4 times.
[b] Grown in single fortieth-acre plats.
[c] Grown in rod rows, usually unreplicated.

Table XI gives the annual and average acre yields in bushels of the spring-wheat varieties that have been grown in twentieth-acre or larger plats during three or more years. The yields in 1911 and 1912 are for single tenth-acre plats. Those in the years from 1913 to 1915, inclusive, are the average yields of duplicate twentieth-acre plats.

TABLE XI.—*Annual and average yields of spring-wheat varieties grown at the Moro substation in twentieth-acre or larger plats for three or more years.*

Variety.	C. I. No.	Yield per acre (bushels).						
		1911	1912	1913	1914	1915	Average.	
							3-year.	5-year.
Aulieata	2407–2	....	....	23.0	22.9	20.2	22.0	....
Blé Noir	2511–2	3.5	7.5	18.0	18.3	23.6	20.0	14.2
Chul	2227–1	11.2	12.9	[a] 22.3	21.5	20.2	21.3	17.6
Early Baart	1697	14.5	19.0	25.0	26.0	26.6	25.9	22.2
Ghirka Spring	1517	....	....	19.6	16.2	26.1	20.7	....
Heine Squarehead	2669–1	....	....	21.6	22.5	23.6	22.6	....
Karun	2200–1	....	....	24.0	25.4	29.4	26.3	....
Koola	2203–2	....	....	25.8	24.2	33.2	27.7	....
Kubanka	1440, 1516	11.0	16.2	16.0	21.5	18.0	18.5	16.5
Little Club	4066	13.1	22.6	19.6	19.2	26.0	21.6	20.1
Marquis	4158	....	....	22.1	22.5	23.1	22.6	....
Pacific Bluestem	4067	11.7	20.2	19.4	20.9	24.0	21.4	19.2
Sonora	3036–2	....	....	15.5	20.5	24.7	20.2	....
Talimka	2495	....	....	27.5	23.0	25.9	25.5	....
Yantagbay	2404–1	9.6	19.0	21.3	19.4	25.2	22.0	18.9
Zacatecas	2799–2	....	....	19.6	21.0	25.2	21.9	....

[a] Yield estimated by comparison with yield of Aulieata in 1914 and 1915.

From Table XI it is seen that several varieties appear to be better than the Pacific Bluestem from the standpoint of yield. The Early Baart exceeded that variety during the five years by an average yield of 3 bushels per acre. The Koola variety exceeded the Bluestem in the 3-year average yield by 6.3 bushels per acre, and for the same period the Karun exceeded the Bluestem by 4.9 bushels per acre.

In Table XII the leading spring wheats grown at the Moro substation during 1913, 1914, and 1915 are arranged in several classes, showing the average yield for each variety and for each class.

TABLE XII.—*Kernel characters and 3-year average yields of leading varieties of spring wheat grown at the Moro substation in 1913, 1914, and 1915, arranged by classes, with the average yield per acre of each variety and of each class.*

Class and variety.	C. I. No.	Character of kernels.	Average yield per acre in bushels, 1913 to 1915.
COMMON AND CLUB.			
Beardless:			
Pacific Bluestem	4067	Soft, white	21.4
Ghirka	1517	Soft, red	20.7
Karun	2200-1	Hard, white	26.3
Little Club	4066	Soft, white	21.6
Marquis	4158	Medium hard, red	22.6
Sonora	3036-2	Soft, white	20.2
Average			22.1
Bearded:			
Aulieata	2407-2	Hard, red	22.0
Chul	2227-1	do	21.3
Early Baart	1697	Soft, white	25.9
Heine Squarehead	2669-1	Soft, red	22.6
Koola	2203-2	Medium hard, red	27.7
Talimka	2495	Hard, amber	25.5
Yantagbay	2404-1	Hard, red	22.0
Zacatecas	2799-2	Soft, red	21.9
Average			23.7
DURUM.			
Blé Noir	2511	Hard, amber	20.0
Kubanka	1516	do	18.5
Average			19.3

Table XII shows that the durum wheats apparently are not so well adapted to the Columbia Basin region as are the common and club varieties. The bearded varieties of common wheats exceeded the yield of the beardless common and club varieties by 1.7 bushels per acre, and the average yield of all common and club wheats exceeded the average yield of the two durum varieties by 3.5 bushels per acre.

DESCRIPTIONS OF THE BEST VARIETIES.

The six varieties of spring wheat which have given the best average results are described and discussed below. Of these varieties, Pacific Bluestem and Little Club are well known and widely grown west of the Rocky Mountains. Early Baart is grown commercially to a small extent in Arizona and Washington, while Karun, Koola, and Talimka are new introductions not yet grown except in an experimental way. Heads of the six varieties are shown in figures 9 and 10.

Pacific Bluestem.—Pacific Bluestem (C. I. No. 4067) is the standard spring wheat on the farms of the Columbia Basin. It usually commands a premium of 3 to 4 cents a bushel over other varieties on western markets. It is a fairly early spring wheat of medium height, with beardless spikes (fig. 9, *B*), white, glabrous glumes, and midsized, soft, white kernels. In the West it is called simply "Bluestem," but it must not be confused with the Bluestems of the hard

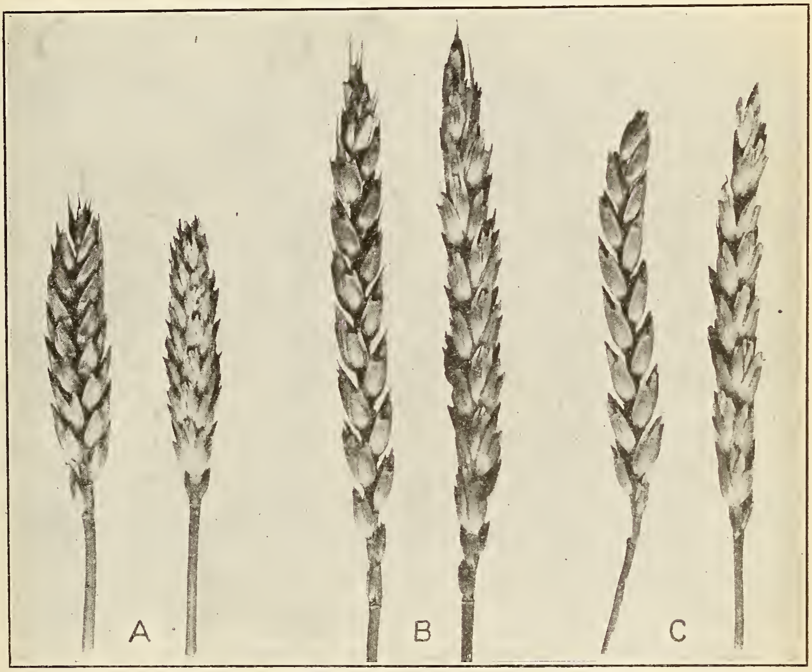

FIG. 9.—Heads of varieties of spring wheat grown at the Moro substation: *A*, Little Club; *B*, Pacific Bluestem; *C*, Karun.

spring-wheat belt in the northern section of the Great Plains area or with the Bluestems of the Atlantic coast. The exact origin of this variety is not known, but almost certainly it is an Australian wheat. It closely resembles Rymer and Warren, two varieties from New South Wales. It is also identical with the White Australian, formerly widely grown in California.

Little Club.—Little Club (C. I. No. 4066) is the standard variety of club wheat in the western United States. It is a short, midseason to late variety, with very broad, short leaves. The beardless spikes are short, but broad and very compact, usually oblong in shape (fig. 9, *A*). The glumes are white and glabrous; the small kernels, white and soft.

The origin of this wheat is not known, but it is supposed to have been introduced into the United States from Mexico or some other portion of Latin America. In the experiments at Moro it has yielded as well or slightly better than Pacific Bluestem, but does not bring as high a price per bushel.

Early Baart.—Early Baart (C. I. No. 1697) is an early-maturing spring wheat, with a fairly short straw. The spikes are bearded (fig. 10, *A*), the glumes white and glabrous, and the kernels white, large, and soft. This variety was introduced into the United States from Australia by the United States Department of Agriculture in 1909. It has been grown to some extent in western Arizona for a

FIG. 10.—Heads of varieties of spring wheat grown at the Moro substation: *A*, Early Baart; *B*, Talimka; *C*, Koola.

number of years, but whether it was introduced into that State by the United States Department of Agriculture or was a separate introduction by some other agency is not known. It was brought to Washington from Arizona, and for this reason is sometimes called "Arizona Baart." It is now being grown commercially at several points in Adams and Lincoln Counties, Washington.

At the Moro substation it has proved to be one of the best and earliest of the spring-wheat varieties. Being a soft wheat, it comes into competition with Pacific Bluestem, Little Club, and others of this class. The bearded heads are objectionable, because they do not pack well in the header boxes, but this disadvantage seems to be more than offset by the better yields obtained. The 5-year average yield of Early Baart has exceeded that of Pacific Bluestem by 3 bushels, while the 3-year average yield exceeds that of the Bluestem by 4.5 bushels per acre.

Karun.—Karun (C. I. No. 2200-1) is a rather dwarf and early-maturing spring wheat, with beardless spikes (fig. 9, *C*), white, glabrous glumes, and midsized, hard, amber-colored kernels. In yield it has ranked second among all the varieties of spring wheat grown at the Moro substation during the 3-year period, 1913 to 1915, inclusive. It has exceeded the Pacific Bluestem in that period by almost 5 bushels per acre. Karun resembles the Bluestem in its beardless, glabrous spikes, but differs particularly in its shorter straw and hard, amber-colored kernels. The original seed of Karun was

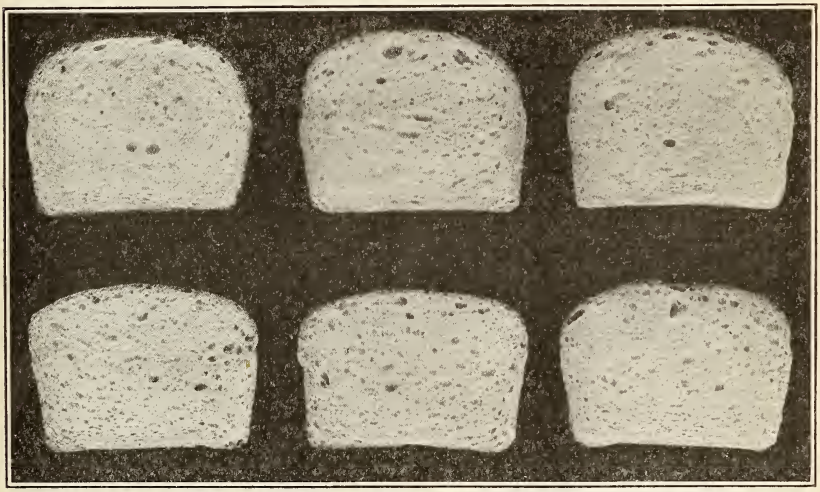

FIG. 11.—Cross sections of loaves of bread made from standard hard spring wheat and from varieties of spring wheat grown at the Moro substation. Left to right: Top row, standard, Marquis, and Bobs; bottom row, Saumur, Karun, and Early Baart.

obtained in Persia by the United States Department of Agriculture in 1902. The variety is not grown commercially, but only on the experimental plats.

Koola.—Koola (C. I. No. 2203-2) is a selection from a low-growing early variety of spring wheat, introduced into the United States from Arabia by the United States Department of Agriculture in 1902. It is a bearded variety (fig. 10, *C*), with white, glabrous glumes, and large, red, soft kernels. It has been tested on experiment farms for several years, but has never been distributed to growers. The Koola variety has given the highest average acre yield of all the spring wheats grown at the Eastern Oregon Dry-Farming Substation during the 3-year period, 1913 to 1915, inclusive. During that time it has outyielded the Pacific Bluestem by 6.3 bushels per acre. It also has proved superior to Pacific Bluestem in milling value during that period.

Talimka.—Talimka (C. I. No. 2495) is an early-maturing, low-growing, bearded spring wheat (fig. 10, *B*), with white, glabrous glumes, and large, flinty, hard, amber kernels. The kernels of this rare variety and of related varieties are so large and so hard that some of them were mistaken for varieties of durum wheat when first introduced. The Talimka variety was obtained in 1904 by a representative of the United States Department of Agriculture at Askabad, Russian Turkestan, where other similar varieties and the closely related varieties of the Chul group are commonly grown also.

At the Moro substation the Talimka variety has proved one of the best yielding of the spring wheats. In a 3-year period, 1913–1915,

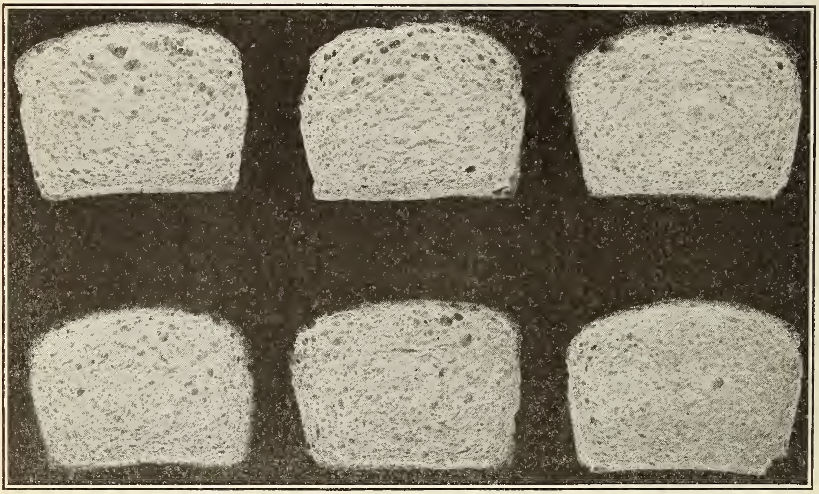

FIG. 12.—Cross sections of loaves of bread made from varieties of hard spring wheat grown at the Moro substation. Left to right: Top row, Koola, Pacific Bluestem, and Chul; bottom row, Yantagbay, Aulieata, and Talimka.

inclusive, its yield has exceeded that of Pacific Bluestem by slightly more than 4 bushels. So far it is grown only in an experimental way.

MILLING AND BAKING EXPERIMENTS.

To ascertain the relative milling and baking values of the spring wheats grown at the substation, tests of several varieties have been made by the Plant Chemical Laboratory of the Bureau of Chemistry. Table XIII gives the data obtained from analyses of the wheats and of flour milled therefrom. Figures 11 and 12 show loaves of bread made from flour milled from spring-wheat varieties grown at the Moro substation in 1915. The loaf labeled "Standard" is from flour milled from one of the hard spring wheats of the northern Great Plains. All the wheats grown at Moro were milled from four to five months after harvest, and the flour was made into bread about two weeks after milling. Miss H. L. Wessling, of the Plant Chemical Laboratory, conducted the baking experiments.

It will be observed from the analyses and photographs of loaves that all of the varieties appear to be equally as good as, and most of them better than, the Pacific Bluestem, which is the standard spring wheat of the Columbia Basin. All the samples from which the flour was made were from the varietal plats and therefore were grown under similar conditions.

TABLE XIII.—*Characteristics of grain and of flours from spring wheats grown at the Moro substation in 1913, 1914, and 1915.*

KERNEL CHARACTERS, CHEMICAL ANALYSES, KERNEL WEIGHTS, AND BUSHEL WEIGHTS OF THE GRAIN.

Variety.	C. I. No.	Kernel color.	Water.	Ash.	Nitrogen.	Protein (N× 5.7).	Alcohol-soluble nitrogen.	Weight.	
								1,000 kernels.	Bushel.
GROWN IN 1913.									
Kernel soft.									
Beardless:			*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Grams.*	*Pounds.*
Pacific Bluestem	4067	White	7.62	1.73	2.39	13.62	1.04	28.4	57.4
Bearded:									
Heine Squarehead	2669	Red	7.61	1.80	2.51	14.31	1.19	24.6	55.5
Rieti	2793	...do	7.74	1.99	2.54	14.48	1.22	28.4	55.0
Koola	2203-2	...do	8.00	1.92	2.52	14.37	1.11	31.3	56.4
Kernel hard.									
Beardless:									
Marquis	4158	...do	7.83	1.80	2.44	13.91	1.03	21.7	55.5
Karun	2200-1	Amber	8.39	1.59	2.36	13.45	.99	32.9	55.7
Bearded:									
Aulieata	2407-2-1	Red	8.06	1.70	2.41	13.74	1.01	34.3	58.3
Yantagbay	2404-1-1	...do	8.06	1.47	2.25	12.83	.94	30.5	57.2
Talimka	2495-1	Amber	8.25	1.55	2.34	13.34	1.00	31.4	56.5
GROWN IN 1914.									
Kernel soft.									
Beardless:									
Pacific Bluestem	4067	White	8.66	2.54	3.34	19.04	1.38	25.7	55.0
Bobs	2826	...do	9.04	1.91	2.98	16.98	1.25	26.7	58.7
Bearded:									
Early Baart	1697	...do	8.05	1.92	2.86	16.30	1.11	25.0	60.8
Heine Squarehead	2669	Red	8.72	2.04	3.13	17.84	1.42	27.8	56.4
Rieti	2793	...do	8.69	1.93	3.41	19.44	1.50	26.6	58.6
Koola	2203-2	...do	8.51	1.99	2.97	16.93	1.28	26.8	55.7
Kernel hard.									
Beardless:									
Marquis	4158	...do	8.24	2.10	3.26	18.58	....	22.6	55.7
Karun	2200-1	Amber	8.32	1.74	2.68	15.28	1.16	27.5	61.2
Bearded:									
Aulieata	2407-2-1	Red	8.32	1.83	2.87	16.36	1.12	35.3	59.7
Chul	2227	...do	8.16	1.87	2.95	16.81	1.14	28.6	55.0
Yantagbay	2404-1-1	...do	7.92	1.79	2.91	16.59	1.14	31.2	56.4
Saumur	2346	Amber	8.61	1.98	3.02	17.21	1.18	19.8	54.9
Talimka	2495-1	...do	8.24	1.89	2.97	16.93	1.23	27.3	56.8
GROWN IN 1915.									
Kernel soft.									
Beardless:									
Pacific Bluestem	4067	White	6.50	1.86	2.68	15.30	....	26.7	52.8
Bobs	2826-1	...do	8.52	1.72	2.80	15.95	....	27.6	60.3
Bearded:									
Early Baart	1697	...do	8.42	1.95	2.60	14.80	....	28.7	59.4
Koola	2203-2	Red	8.60	2.14	2.97	16.90	....	24.3	52.5

TABLE XIII.—*Characteristics of grain and of flours from spring wheats grown at the Moro substation in 1913, 1914, and 1915*—Continued.

KERNEL CHARACTERS, CHEMICAL ANALYSES, KERNEL WEIGHTS, AND BUSHEL WEIGHTS OF THE GRAIN—Continued.

Variety.	C. I. No.	Kernel color.	Water.	Ash.	Nitrogen.	Protein (N × 5.7).	Alcohol-soluble nitrogen.	Weight.	
								1,000 kernels.	Bushel.
GROWN IN 1915—Continued.									
Kernel hard.									
Beardless:			*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Grams.*	*Pounds.*
Marquis	4158	Red	8.23	2.42	3.26	18.60	....	16.0	52.7
Karun	2200-1	Amber	8.46	1.58	2.67	15.20	....	24.5	61.0
Bearded:									
Aulieata	2407-2-1	Red	6.61	2.12	2.95	16.80	....	27.2	53.7
Chul	2227-1	...do	6.67	1.89	2.81	16.00	....	24.5	55.0
Yantagbay	2404-1	...do	7.00	1.99	2.85	16.25	....	29.2	54.8
Saumur	2346-1	Amber	8.16	2.07	2.97	16.90	....	20.6	53.2
Talimka	2495-1	...do	6.74	1.98	2.97	16.90	....	26.7	56.4
AVERAGES.									
Kernel soft.									
Beardless:									
Pacific Bluestem	4067	White	7.59	2.05	2.80	15.99	....	26.9	55.1
Bobs [a]	2826	...do	8.78	1.82	2.89	16.47	....	27.2	59.5
Bearded:									
Early Baart [a]	1697	...do	8.24	1.94	2.73	15.55	....	26.9	60.1
Heine Squarehead [a]	2669	Red	8.17	1.92	2.82	16.08	....	26.2	55.9
Rieti [a]	2793	...do	8.22	1.96	2.98	16.96	....	28.5	56.8
Koola	2203-2	...do	8.37	2.02	2.82	16.07	....	27.5	54.9
Kernel hard.									
Beardless:									
Marquis	4158	...do	8.10	2.11	2.99	17.03	....	20.1	54.8
Karun	2200-1	Amber	8.39	1.64	2.57	14.64	....	28.3	59.3
Bearded:									
Aulieata	2407-2-1	Red	7.66	1.88	2.74	15.93	....	32.3	57.2
Chul [a]	2227	...do	7.47	1.88	2.88	16.41	....	53.1	55.0
Yantagbay	2404-1-1	...do	7.66	1.75	2.67	15.22	....	30.3	56.1
Saumur [a]	2346	Amber	8.39	2.03	3.00	17.06	....	20.2	54.1
Talimka	2495-1	...do	7.74	1.81	2.76	15.72	....	28.5	56.6

CHEMICAL ANALYSES AND BAKING QUALITIES OF THE FLOUR.

Variety.	Cereal Investigations No.	Water.	Ash.	Nitrogen.	Water-soluble nitrogen.	Alcohol-soluble nitrogen.	Protein (N × 5.7).	100 grams of flour.		Loaf.	
								Water absorbed.	Maximum expansion.	Color. [b]	Texture.
Grown in 1913:		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*C. c.*	*C. c.*	*P. ct.*	*P. ct.*
Pacific Bluestem	4067	11.83	0.448	1.90	0.295	1.05	10.83	64.5	400	c94	88
Heine Squarehead	2669	11.83	.516	2.17	.203	1.25	12.37	69.0	445	c93	[c] 90
Rieti	2793	11.72	.548	2.19	.267	1.29	12.48	67.5	550	c93	86
Koola	2203-2	11.80	.464	2.07	.203	1.09	11.80	69.0	400	95	87
Marquis	4158	11.78	.396	2.20	.267	1.12	12.54	71.0	660	96	96
Karun	2200-1	11.55	.428	2.07	.160	1.20	11.80	74.5	585	c95	[d] 93
Aulieata	2407-2-1	11.79	.400	2.07	.204	1.12	11.80	73.7	590	95	93
Yantagbay	2404-1-1	11.69	.392	1.98	.246	1.07	11.29	71.8	620	c96	94
Talimka	2495-1	11.81	.428	2.07	.154	1.10	11.80	72.5	580	c95	93
Standard	....	......	......	......	....	......	11.05	71.5	810	97	98
Grown in 1914:											
Pacific Bluestem	4067	10.53	.580	2.57	.337	.751	14.65	67.0	380	g93	95
Bobs	2826	10.91	.490	2.72	.390	.730	15.50	67.0	620	99	98
Early Baart	1697	11.29	.570	2.27	.358	.596	12.94	62.0	585	g94	98
Heine Squarehead	2669	10.96	.550	2.72	.347	.826	15.50	65.0	480	g94½	94
Rieti	2793	10.76	.540	3.05	.386	.870	17.39	68.0	420	g92½	92
Koola	2203-2	12.06	.590	2.54	.372	.709	14.48	65.0	405	g92	94

[a] Data for 2 years only.
[b] Abbreviations: c=creamy, vc=very creamy, g=gray.
[c] Stiff.
[d] Spongy.

TABLE XIII.—*Characteristics of grain and of flours from spring wheats grown at the Moro substation in 1913, 1914, and 1915*—Continued.

CHEMICAL ANALYSES AND BAKING QUALITIES OF THE FLOUR—Continued.

Variety.	Cereal Investigations No.	Water.	Ash.	Nitrogen.	Water-soluble nitrogen.	Alcohol-soluble nitrogen.	Protein (N × 5.7).	100 grams of flour.		Loaf.	
								Water absorbed.	Maximum expansion.	Color.[a]	Texture.
Grown in 1914—Continued.		*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*C. c.*	*C. c.*	*P. ct.*	*P. ct.*
Marquis	4158	10.25	0.590	2.61	0.358	0.793	14.88	69.0	585	96	96½
Karun	2200-1	11.43	.530	2.36	.281	.681	13.45	68.0	580	c97	96
Aulieata	2407-2-1	10.83	.580	2.55	.302	.702	14.54	70.0	620	96	96
Chul	2227	11.48	.470	2.53	.323	.667	14.42	68.0	580	c96	98
Yantagbay	2404-1-1	12.31	.440	2.54	.309	.681	14.48	69.0	565	96	96
Saumur	2346	11.97	.500	2.61	.338	.737	14.88	70.0	555	c95	92
Talimka	2495-1	10.78	.490	2.61	.344	.716	14.88	70.0	595	c97	97
Standard	....	11.75	.410	2.08	.347	.582	11.86	65.0	840	c98	98
Grown in 1915:											
Pacific Bluestem	4067	12.51	.436	2.17	....	......	12.37	64.0	470	97½	96
Bobs	2826-1	12.05	.403	2.44	....	......	13.90	66.4	590	c98	97
Early Baart	1697	11.14	.489	2.27	....	......	12.94	66.0	500	c97	95
Koola	2203-2	11.28	.474	2.51	....	......	14.30	69.0	510	96	95
Marquis	4158	11.39	.490	2.77	....	......	15.80	68.0	610	g97	97
Karun	2200-1	11.50	.456	2.34	....	......	13.35	65.5	520	vc97	94
Aulieata	2407-2-1	12.66	.483	2.52	....	......	14.36	68.0	660	c96	96½
Chul	2227-1	12.12	.466	2.46	....	......	14.00	67.0	610	c96	97
Yantagbay	2404-1	12.49	.428	2.42	....	......	13.80	69.0	600	c96	96½
Saumur	2346-1	11.12	.481	2.60	....	......	14.82	69.0	580	vc97	94
Talimka	2495-1	11.78	.420	2.47	....	......	14.08	67.0	610	c97	97
Standard	....	....	......	......	....	......	10.43	66.0	840	c98	99
Average:											
Pacific Bluestem	4067	11.62	.488	2.21	....	......	12.62	65.2	417	94.8	93.0
Bobs[b]	2826	11.48	.447	2.58	....	......	14.70	66.7	605	98.5	97.5
Early Baart[b]	1697	11.22	.530	2.27	....	......	12.89	64.0	543	95.5	96.5
Heine Squarehead[b]	2669	11.40	.533	2.45	....	......	13.94	67.0	463	93.8	92.0
Rieti[b]	2793	11.24	.544	2.62	....	......	14.97	67.8	485	92.8	89.0
Koola	2203-2	11.75	.443	2.37	....	......	13.53	68.0	438	94.0	92.0
Marquis	4158	11.14	.492	2.53	....	......	14.41	69.0	618	96.0	96.5
Karun	2200-1	11.49	.471	2.26	....	......	12.87	69.3	562	96.3	94.3
Aulieata	2407-2-1	11.76	.488	2.38	....	......	13.57	70.6	623	96.6	95.1
Chul[b]	2227	11.80	.468	2.50	....	......	14.21	67.5	595	96.0	97.5
Yantagbay	2404-1-1	12.16	.420	2.31	....	......	13.19	69.9	595	96.0	95.5
Saumur[b]	2346	11.55	.491	2.605	....	......	14.85	69.5	568	96.0	93.0
Talimka	2495-1	11.46	.446	2.38	....	......	13.59	69.8	595	96.3	95.6
Standard	....	[c]11.75	[c].410	[c]2.08	....	......	11.11	67.5	830	97.6	98.3

[a] Abbreviations: c=creamy, vc=very creamy, g=gray.
[b] Average data for 2 years only.
[c] Data for 1 year only.

RATE-OF-SEEDING AND DATE-OF-SEEDING EXPERIMENTS.

During the years 1912 to 1915, inclusive, rate-of-seeding and date-of-seeding experiments with spring wheat were conducted with the Pacific Bluestem variety. This wheat was sown at rates varying from 2 to 8 pecks per acre on each of two dates, one early and one late in the spring. Unreplicated tenth-acre plats were used, except in 1915, when all seedings were made on duplicate twentieth-acre plats. The 8-peck rate was omitted in 1912 and the 2-peck rate in 1915. Table XIV gives the yields obtained in each year, the average yield from each rate on both dates and on each date in all years, and the average yield of all rates from each date.

Table XIV shows that there is little difference in the average yield per acre from the different rates of seeding during the four years. The early seeding, however, gave much higher yields than the later seeding in every year except 1912. The average increase in yield from the early seeding in the four years was 6.2 bushels per acre. In the early seeding the thickest rate (8 pecks) gave the highest average yield, and in the late seeding the 3-peck rate gave the highest average yield. The average date of the early seeding was March 22 and of the late seeding, April 20.

TABLE XIV.—*Annual and average yields obtained in a rate-of-seeding test of Pacific Bluestem wheat sown on two dates at the Moro substation during the 4-year period, 1912 to 1915, inclusive.*

Year and date of seeding.	Yields per acre (bushels) at given rates of seeding.							
	2 pecks.	3 pecks.	4 pecks.	5 pecks.	6 pecks.	7 pecks.	8 pecks.	Average.
Season of 1912:								
Early (Mar. 25)	7.0	8.8	13.6	12.5	10.5	13.1	....	10.9
Late (Apr. 26)	7.8	15.5	11.8	14.0	15.1	15.5	....	13.3
Season of 1913:								
Early (Mar. 25)	18.5	17.5	20.8	21.3	18.3	20.0	20.0	19.5
Late (Apr. 25)	10.5	10.0	7.7	7.6	8.3	10.4	13.1	9.7
Season of 1914:								
Early (Mar. 16)	17.5	15.5	14.5	17.8	16.3	17.3	18.1	16.7
Late (Apr. 16)	13.7	11.7	8.7	5.3	3.7	4.0	3.7	7.3
Season of 1915:								
Early (Mar. 22)	....	18.6	15.1	17.2	20.6	18.0	19.2	18.1
Late (Apr. 15)	....	10.4	11.1	10.5	11.4	12.8	10.2	11.1
Average yields:								
All dates	12.5	13.5	12.9	13.3	13.3	13.9	14.0	....
Early seeding	14.3	15.1	16.0	17.2	16.4	17.1	19.1	16.3
Late seeding	10.6	11.9	9.8	9.4	9.6	10.7	9.0	10.1

On April 9, 1913, and April 6, 1914, eight check plats were sown with the same variety, Pacific Bluestem, at the rate of 5 pecks per acre. This provided a medium date of seeding to compare with the early and late dates discussed above. The earliest seeding at the rate of 5 pecks per acre gave higher yields in both years than any check plat, further indicating the advantage of early seeding.

SPRING OATS.

From the standpoint of total production, oats are a less important crop than wheat and barley in the Columbia Basin. Judging from yields obtained at the substation at Moro, oats probably have not received the attention they deserve from the farmers of this section. This undoubtedly is due to the fact that the header and the combined harvester-thrasher, the harvesting machines most commonly used in the Columbia Basin, are not adapted to the economical handling of this crop. Grain must be thoroughly ripe before it is cut with a header or thrashed with a combined harvester-thrasher. Much of the oat crop is lost through shattering if left too long after maturity before it is harvested. The oat varieties at the substation have always been cut with a binder and thrashed from the shock.

VARIETAL EXPERIMENTS.

In 1912 the oat varietal experiment was on spring-disked corn ground. In the other years reported the oats were grown on ground summer tilled the previous year, as in the case of the spring barley and wheat.

The results of the test of oat varieties that have been grown for two or more years are presented in Table XV, with the annual yield in bushels per acre produced by each.

TABLE XV.—*Annual yields of 20 varieties and strains of spring oats grown in field plats at the Moro substation during two or more years in the 5-year period, 1911 to 1915, inclusive.*

Variety.	C. I. No.	Period of maturity.	Yield per acre (bushels).				
			1911	1912	1913	1914	1915
Banner	160	Midseason	17.1	38.4	36.3	......	......
Black American	549	....do	35.1	35.1	42.5	33.8	43.3
Canadian	444	....do	17.1	38.4	46.4	45.2	48.9
Danish Island	519	....do	......	......	......	33.1	49.0
Kherson	459	Early	28.9	39.6	43.6	54.2	52.6
Shadeland Challenge	680	Late	......	17.3	31.2	......	......
Shadeland Climax	681	Midseason	......	44.3	36.5	35.1	55.3
Siberian	635	....do	30.8	35.6	53.7	37.0	58.3
Sixty-Day	165	Early	18.7	40.0	47.8	52.3	57.8
Sixty-Day 4P4	789	....do	11.2	37.1	66.5	33.7	......
Sixty-Day selection	165-1	....do	......	......	......	65.6	57.2
Do	165-1-1	....do	......	......	45.6	61.9	57.1
Do.[a]	165	....do	......	27.8	47.2	......	......
Storm King	522-1	Midseason	......	......	46.2	35.6	63.0
Swedish Select	134	....do	13.5	37.0	40.7	37.2	47.0
Swedish Select selection	134-1	....do	......	......	40.6	37.9	52.0
Tartar King	523	....do	......	......	29.4	35.0	......
White Russian	636	Late	13.7	28.1	30.0	......	......
Local variety [b]	795	Midseason	14.3	......	44.1	38.4	51.4
Unnamed	357-1	....do	......	......	......	45.0	49.2

[a] Selection from the branch experiment station, Union, Oreg.
[b] An unnamed variety grown locally; similar to Siberian.

DESCRIPTIONS OF THE BEST VARIETIES.

Table XVI shows the 3-year and 5-year average yields of 11 of the more important varieties and gives certain other data regarding these varieties. This table shows that the 5-year average yield of the Kherson is highest, though there is little difference in the 5-year average yield of the Kherson and that of the Sixty-Day and Siberian. In the 3-year average, the Sixty-Day and a selection from Sixty-Day show the highest yields.

TABLE XVI.—*Agronomic data and 3-year and 5-year average yields for the 11 most important varieties and selections of spring oats tested at the Moro substation during three or more years in the 5-year period, 1911 to 1915, inclusive.*

Variety.	C. I. No.	Date headed.	Date ripe.	Height.	Bushel weight.	Average yield per acre.	
						3 years.	5 years.
				Inches.	*Pounds.*	*Bushels.*	*Bushels.*
Sixty-Day selection	165-1-1	June 16	July 9	28	30.7	54.9	....
Kherson	459	June 18	July 13	26	30.0	50.1	43.8
Sixty-Day	165	...do	July 12	26	30.7	52.6	43.3
Siberian	635	June 27	July 20	34	34.0	49.7	43.1
Storm King selection	522-1	...do	July 18	33	33.0	48.3	....
Canadian	444	June 26	...do	33	36.5	46.8	39.2
Local variety	795	June 29	July 20	32	28.4	44.6	....
Swedish Select selection	134-1	June 26	July 18	33	32.4	43.5	....
Shadeland Climax	681	July 1	July 21	32	33.3	42.3	....
Black American	549	June 28	...do	28	28.6	39.9	38.0
Swedish Select	134	June 26	July 20	32	32.7	41.6	35.1

Kherson and Sixty-Day.—The Kherson and Sixty-Day are very similar varieties of oats which came originally from southern Russia. The Kherson was introduced about 20 years ago from the Kherson

FIG. 13.—Heads of oats grown at the Moro substation: *A*, Swedish Select, *B*, Kherson.

Government, and the Sixty-Day about 15 years ago from the Podolia Government. These oats are both early in maturing, ripening at Moro about the second week in July. The straw is slender and usually rather short. The heads are small, spreading (fig. 13), and usually well filled with slender, yellow kernels. While the weight per bushel is sometimes rather low, the percentage of hull is lower than in most varieties of oats. The Sixty-Day selection which has given the highest 3-year average yield at Moro does not differ in appearance from the unselected variety. The principal objections to these early oats are the small size of the kernel and the shortness of the straw. Because of the short straw it is sometimes difficult to harvest them with a binder. When the oat crop is to be cut for

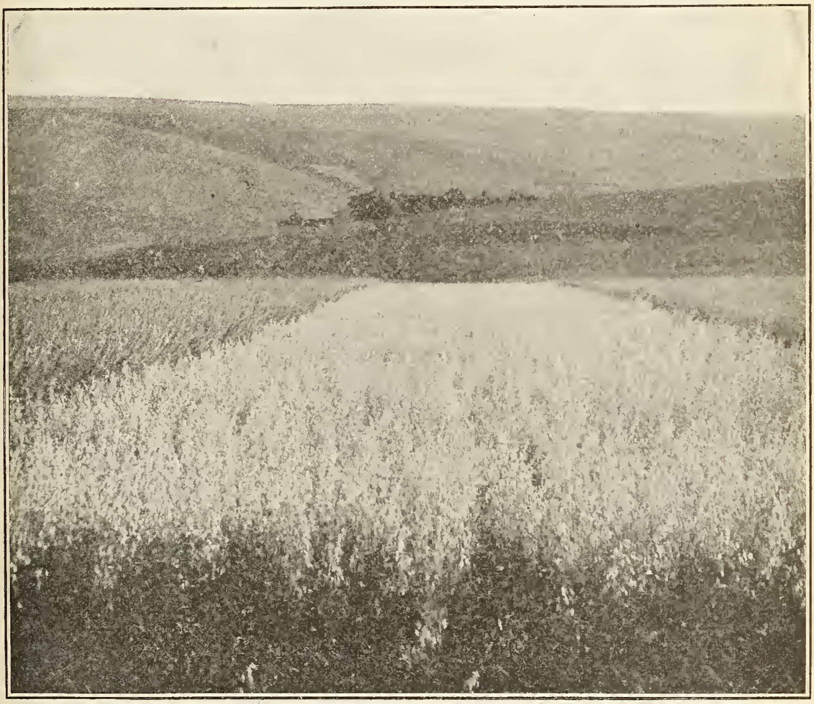

FIG. 14.—A twentieth-acre plat of Sixty-Day oats at the Moro substation in 1914.

hay, some other variety with larger, taller straw should be grown. A plat of Sixty-Day oats at the Moro substation is shown in figure 14.

Siberian.—The Siberian is an old European variety. The stock grown at the Moro substation was obtained a number of years ago from the Ontario Agricultural College, where this variety has been a leading one for many years. The Siberian variety ripens at Moro about 8 or 10 days later than the Kherson and Sixty-Day. It is a tall, rather slender strawed variety, with open heads. The kernels are white, long, and slender, but are considerably larger than those of the Kherson and Sixty-Day varieties. The average weight per bushel at Moro was 34 pounds, which is second only to that of the

Canadian. The 5-year average yield was only slightly less than that of the Sixty-Day and Kherson, exceeding that of any other variety by several bushels. A head of the Siberian oat is shown in figure 15.

FIG. 15.—Heads of oats grown at the Moro substation: *A*, Siberian; *B*, Canadian.

Canadian.—The Canadian is a variety of oats which has been grown for many years in Scotland and in some portions of northern Europe as the Barley oat, so called because of its short, broad kernels, which somewhat resemble a grain of barley. The Canadian ripens at Moro about a week later than the Kherson and Sixty-Day, but two or three days earlier than most other varieties. The straw is tall and coarse, and the heads are very large and open (fig. 15). The kernels are white, short, and broad. The two prominent characteristics of this variety are the wide-spreading heads and the short kernels. One of its principal faults is a tendency to produce only one grain to the spikelet, the second or smaller grain often being entirely inclosed in the hull of the first. That this tendency has not been marked at the Moro substation is shown by the weight per bushel, which is higher than that of any other variety.

SPRING BARLEY.

Next to wheat, barley is the most important cereal grown on the dry lands of the Columbia Basin. Most of the barley grown is sown in the spring, though at the lower elevations winter barley is grown successfully.

VARIETAL EXPERIMENTS.

At the substation 43 varieties of spring barley have been tried. Acre yields have been obtained from 13 of these in each of the five years, 1911 to 1915, inclusive. Owing to an exceedingly unfavorable season the barley yields were low in 1911. In 1912 the spring-barley varieties were placed on poor soil and no high yields were obtained. In 1913, 1914, and 1915 the yields of most of the varieties were considerably higher than in previous years, and spring barley exceeded any other spring crop in total weight of grain produced per acre.

In Table XVII will be found an alphabetical list of the spring-barley varieties grown two or more years, with the yields of each variety in bushels per acre. These yields are based on the yields of single tenth-acre plats in 1911, 1912, and 1913 and of duplicate twentieth-acre plats in 1914 and 1915, except as otherwise stated.

TABLE XVII.—*Yields of varieties of spring barley grown in rows and plats of various sizes at the Moro substation within the 5-year period, 1911 to 1915, inclusive, showing also the source of seed and group relationships.*

Variety.	C. I. No.	Origin.	Group.	Yield per acre (bushels).				
				1911	1912	1913	1914	1915
Abyssinian	668	Abyssinia	2-rowed	(a)	(a)	b 35.0	b 22.1	b 20.8
Do	669	do	6-rowed	(a)	(a)	b 32.5	b 22.1	b 18.2
Do	673	do	do	(a)	(a)	b 32.5	c 14.1	
Do	674	do	do	(a)	(a)	b 23.1	b 3.9	
Arlington	702	Hybrid, Virginia.	do		(a)	b 32.5	b 15.6	c 26.5
Barbary	695	Northern Africa.	do	(a)	(a)	(a)	b 32.5	c 28.5
Beldi	190	Algeria	do	3.5	15.5	37.5	36.2	48.8
Black Abyssinian	670	Abyssinia	do	(b)	(a)	b 40.3	b 11.7	b 16.0
Black Algerian	708-1	Algeria	do		b 22.8	c 39.3	46.3	46.4
Black Hull-less	596	Southwestern Asia.	do	3.7	17.8	37.9	25.2	36.6
Do		Hybrid, Oregon.	6-rowed, hooded.		20.7	33.1	23.3	27.0
Bohemian	27-1	Austria	2-rowed	(a)	(a)	b 25.0	c 3.2	b 4.0
Chevalier II	200	Sweden	do	6.4	26.2	31.0	21.8	32.5
Chili Brewing	657-1	Chili	6-rowed	(a)	b 26.0	c 35.2	23.7	47.5

a Grown in head rows; yield not recorded.
b Grown in rod rows, usually unreplicated.
c Grown in 2-rod rows replicated 2 to 4 times.

TABLE XVII.—*Yields of varieties of spring barley grown in rows and plats of various sizes at the Moro substation within the 5-year period, 1911 to 1915, inclusive, showing also the source of seed and group relationships*—Continued.

Variety.	C. I. No.	Origin.	Group.	Yield per acre (bushels).				
				1911	1912	1913	1914	1915
Coast	691	California (?)	6-rowed	....	....	(b)	37.9	42.6
Do	626	do	do	2.9	23.3	38.3	32.5	51.2
Common Chili	663	Chili	do	(a)	b 31.2	c 25.0	....	....
Franconian	679	Germany	2-rowed	(a)	(a)	b 45.5	29.2	47.5
Gatami	575	China	6-rowed	5.9	16.8	36.4	41.2	36.0
Gray Abyssinian	672	Abyssinia	do	(a)	b 35.1	c 30.6	b 22.8	b 20.8
Hanna	24	Austria	2-rowed	10.0	26.0	29.5	26.9	40.0
Hannchen	531	Sweden	do	8.4	25.2	48.3	32.8	46.4
Heil's Hanna No. 1	681	Germany	do	(a)	(a)	b 32.5	b 28.3	c 21.9
Heil's Hanna No. 2	678	do	do	(a)	(a)	b 20.8	b 24.7	c 5.0
Heil's Hanna No. 3	682	do	do	(a)	(a)	b 48.1	....	....
Horsford (Texas Beardless).	610	Texas (?)	do	5.4	24.5	14.4	20.8	22.5
Himalaya (Guy Mayle)	260-1	China	6-rowed	2.9	6.0	33.8	25.0	42.2
Imperial	289	France	2-rowed	4.3	25.0	17.3	....	....
Mahan	1144	North Dakota	do	12.0	22.0	25.1	28.0	36.0
Manchuria (Minn. No. 105)	576	China	6-rowed	....	23.9	33.0	34.6	27.0
Manchuria (Minn. No. 6)	638	do	do	....	....	34.3	25.4	....
Manchuria (O. A. C. No. 21).	....	do	do	....	....	34.0	23.4	....
Mandschurei (O. A. C.)	....	do	do	....	....	38.7	29.2	27.2
Mansury	617	North Dakota (?).	2-rowed	2.7	21.2	31.2	24.2	....
Mariout	261	Egypt	6-rowed	6.3	28.0	40.6	42.1	54.5
Oderbrucker	537	Germany	do	7.0	23.5	30.6	34.5	41.5
Peru	707	Peru	do	(a)	(a)	b 46.8	40.4	48.3
Princess	529	Sweden	2-rowed	4.6	21.5	24.0	17.5	....
Do	603	do	do	2.0	19.1	17.0	20.8	....
Salamanca	689	Spain	6-rowed	13.8	(a)	b 11.7	(a)	....
Svanhals	187	Sweden	2-rowed	16.5	5.1	34.1	30.6	38.7
White Smyrna (Ouchac)	658	Asia Minor	do	9.3	(a)	42.0	36.7	49.8
Wisconsin No. 9	....	Wisconsin	6-rowed	....	22.3	25.4	....	....

a Grown in head rows; yield not recorded.
b Grown in rod rows, usually unreplicated.
c Grown in 2-rod rows replicated 2 to 4 times.

Table XVIII gives acre yields of the varieties that have been tested during the entire five years. The highest average yield per acre, 34.3 bushels, was obtained from the Mariout variety (C. I. No. 261), a 6-rowed form. The varieties giving the second and third highest average yields were White Smyrna (C. I. No. 658) and Hannchen (C. I. No. 531), both of which are 2-rowed barleys.

TABLE XVIII.—*Annual and average yields of 13 spring-barley varieties grown at the Moro substation in twentieth-acre or larger plats during the 5-year period, 1911 to 1915, inclusive.*

Variety.	C. I. No.	Yield per acre (bushels).					
		1911	1912	1913	1914	1915	Average.
Black Hull-less	596	3.7	17.8	37.9	25.2	36.6	24.2
Beldi	190	3.5	15.5	37.5	36.2	48.8	28.3
Chevalier	200	6.4	26.2	31.0	21.8	32.5	23.6
Coast	626	2.9	23.3	38.3	32.5	51.2	29.6
Gatami	575	5.9	16.8	36.4	41.2	36.0	27.8
Hannchen	531	8.4	25.2	48.3	32.8	46.4	32.2
Hanna	24	10.0	26.0	29.5	26.9	40.0	26.5
Mariout	261	6.3	28.0	40.6	42.1	54.5	34.3
Mahan	1144	12.0	22.0	25.1	28.0	36.0	24.6
Manchuria (Minn. No. 105)	576	a 6.4	23.9	33.0	34.6	27.0	29.6
Oderbrucker	537	7.0	23.5	30.6	34.5	41.5	29.4
Svanhals	187	13.8	25.1	34.1	30.6	38.7	28.5
White Smyrna	658	9.3	27.0	42.0	36.7	49.8	33.0

a Estimated yield by comparison with yield of other varieties during 1912, 1913, 1914, and 1915.

In Table XIX the spring-barley varieties are arranged in groups of related varieties, showing the 5-year average yield of each variety and the average yield of each group. Typical heads of the leading varieties of barley at the Moro substation are shown in figure 16.

TABLE XIX.—*Average yields of spring-barley varieties grown at the Moro substation for the 5-year period, 1911 to 1915, inclusive, arranged in groups of related varieties.*

Groups.	C. I. No.	Yield per acre.
1. Six-rowed (hulled):		*Bushels.*
Beldi	190	28.3
Coast (Common California)	626	29.6
Gatami	575	27.8
Manchuria (Minn. No. 105)	576	29.6
Mariout	261	34.3
Oderbrucker	537	29.4
Average		29.8
2. Six-rowed naked (hull-less):		
Black Hull-less	596	24.2
Black Hull-less (Union, Oreg.)		[a] 26.0
Average		22.8
3. Two-rowed (hulled):		
Chevalier	200	23.6
Hannchen	531	32.2
Hanna	24	26.5
Mahan	1144	24.6
Svanhals	187	28.5
White Smyrna	658	33.0
Average		28.0

[a] Average yield for four years only, 1912–1915. The average yield of Black Hull-less (C. I. No. 596) in the same four years was 29.4 bushels.

DESCRIPTIONS OF THE BEST VARIETIES.

The 6-rowed varieties.—The leading 6-rowed varieties, as shown in Table XIX, are Mariout, Coast, Oderbrucker, and Beldi. Heads of the first three varieties are shown in figure 16.

The Mariout (C. I. No. 261) is an Egyptian variety which is characterized by a compact spike of the type often called club, although it possesses this characteristic to a lesser degree than the White Club. The kernel is somewhat coarse and the beard is not always entirely broken off in thrashing. It is an early, heavy-yielding variety in this section.

The Coast variety (C. I. No. 626) is the common 6-rowed barley grown upon the Pacific slope and in the Columbia Basin. It is called by various names, such as Common California, Bay Brewing, and sometimes Blue barley. The spike is less compact than that of the Mariout, and in many localities the plant is somewhat taller. Like the Mariout, the awn is not entirely removed in thrashing. It is a large-kerneled, heavy-yielding variety. It has been grown for many years in the western United States and probably came originally from Egypt.

Beldi (C. I. No. 190) is another North African variety, which closely resembles the Coast. It is, however, slightly earlier, and the spike and straw are somewhat shorter.

The 2-rowed varieties.—Of the 2-rowed varieties the Hannchen, White Smyrna, and Svanhals have given the best results. Heads of the Hannchen and White Smyrna barleys are shown in figure 16.

The Hannchen (C. I. No. 531) is a 2-rowed variety, with a narrow, nodding spike. It was produced by the Swedish Plant-Breeding Association of Svalof, Sweden, and was a selection from Hanna. Throughout most of the northern United States it is somewhat earlier than Hanna and a better yielder.

FIG. 16.—Heads of five varieties of spring barley grown at the Moro substation: *A*, Coast; *B*, Mariout; *C*, Oderbrucker; *D*, White Smyrna; *E*, Hannchen.

White Smyrna (C. I. No. 658) came originally from Asia Minor. It is a very large kerneled, 2-rowed variety, with a nodding spike. It has a very short straw, and for this reason often gives an unfavorable impression when first seen. It can be harvested successfully, however, and is a very heavy yielding variety. It is early, stands drought well, and is well adapted to the Columbia Basin uplands.

The variety Svanhals (C. I. No. 187) was produced by the Swedish Plant-Breeding Association. It has a wide, erect, 2-rowed spike, with large kernels and a stiff straw. It very seldom lodges, and it gives satisfactory yields throughout most of the western United States, but is hardly equal to the Hannchen and White Smyrna in this respect. This variety has been rather widely distributed under the name Swanneck, which is a translation of the Swedish name.

COMPARATIVE VALUE OF WHEAT, OATS, AND BARLEY.

Table XX gives comparative figures on the acre yields of three spring crops, wheat, barley, and oats, and the pound values and acre values of these crops. The price per pound is based on the average price of these cereals in Oregon on December 1 in the 10 years, 1905 to 1914, inclusive, as given by the Bureau of Crop Estimates.[1] The average yields in this table are those obtained in plat tests at the Moro substation during 1913, 1914, and 1915. The average yields and the acre values for the leading variety of each crop in the five years, 1911 to 1915, inclusive, are also given.

TABLE XX.—*Average acre yields of all spring wheat, oat, and barley varieties grown at the Moro substation in 1913, 1914, and 1915, and of the best variety of each for the 5-year period, 1911 to 1915, inclusive, with average values based on the average farm price of these cereals in the 10-year period, 1905 to 1914, inclusive.*

Crop.	Price per pound.	Average for all varieties, 1913 to 1915.		Best variety, 1911 to 1915.		
		Yield per acre.	Value per acre.	Name.	Yield per acre.	Value per acre.
	Cents.	*Pounds.*			*Pounds.*	
Spring barley	1.23	1,572	$19.33	Mariout	1,646	$20.35
Spring oats	1.38	1,485	20.49	Kherson	1,402	19.35
Spring wheat	1.35	1,296	17.50	Early Baart	1,362	18.39

Table XX shows that oats lead in value per acre of the three cereals for the three years, 1913 to 1915, barley being second and wheat third.

There is little difference in acre value between the crops when only the highest yielding variety of each crop is considered. Both oats and barley, however, have given higher yields in pounds per acre than spring wheat, and the value per acre based on the 10-year average farm price of these highest yielding varieties is highest for the barley, with oats $1 and wheat $1.96 per acre less.

SPRING EMMER.

Spring emmer has had a thorough trial at the substation. It is apparently less drought resistant than wheat, oats, and barley. The acre yields have been considerably less than those of most varieties of other spring grains. Spring emmer (frequently advertised as spelt by seed companies) is apparently not so well adapted to Columbia Basin conditions as either oats or barley.

[1] Statistics of principal crops. U. S. Dept. Agr. Yearbook, 1915, p. 423, 435, 441. 1916.

One variety (C. I. No. 1524) has been tested since 1911, and the highest acre yield has been 31.5 bushels of 32 pounds each. The average yield in the five years was 21.8 bushels per acre, or less than half the number of pounds per acre yielded by Kherson oats or Mariout barley in the same period.

GRAIN SORGHUMS.

Several varieties of the grain sorghums, including Manchu and White kaoliang, milo, feterita (Sudan durra), and kafir, have been tried, but with the exception of Manchu kaoliang all have been discarded. The cold spring weather in this section makes it difficult to secure good stands of most varieties of sorghums.

The Manchu kaoliang has given the best results, but the yields have not been large enough to recommend this crop for trial by farmers.

Two varieties of broom corn have also been grown. Fair seed yields have been obtained, but the brush produced has been of poor quality.

SUMMARY.

Cooperative experiments with cereals have been conducted at the Moro substation during the five years, 1911 to 1915, inclusive.

Moro is located in Sherman County, in the north-central part of Oregon, on the rolling hills of the Columbia Basin, about 15 miles from the Columbia River.

The elevation of the substation is approximately 2,000 feet. The soil and climate are typical of a large part of the Columbia Basin in Oregon and Washington.

The average annual precipitation at or near Moro in the past 11 years has been 11.35 inches. The average seasonal precipitation (March to July, inclusive) in the five years, 1911 to 1915, inclusive, was 3.83 inches.

The average evaporation from a free water surface was 45.07 inches during the seven months, April to October, inclusive, in the five years, 1911 to 1915, inclusive.

The ratios of evaporation to seasonal precipitation and to annual precipitation are higher at the Moro substation than at the substations at Nephi, Utah, or Moccasin, Mont.

The average frost-free period in the five years, 1911 to 1915, inclusive, was 155.8 days. The average date of the last frost (32° F.) in the spring was May 2, and of the first frost in the fall, October 5.

The average wind velocity for the years 1911 to 1915, inclusive, was 5.9 miles per hour.

The experimental work with grains at the Moro substation includes varietal testing and breeding, crop rotation, and tillage experiments. Only the results of varietal experiments with spring grains are reported in this bulletin.

Seventy-six varieties of spring wheat have been tested for two or more years. Early Baart wheat (C. I. No. 1697) produced the highest average yield, 22.2 bushels per acre, in the five years, 1911 to 1915, inclusive. The selection from Koola (C. I. No. 2203–2) gave the highest three-year average yield, 27.7 bushels per acre, in the years 1913, 1914, and 1915.

The average yield of 14 varieties of common and club wheat varieties in 1913, 1914, and 1915 exceeded the average yield of two durum varieties by 3.5 bushels per acre. The average yield of the highest yielding common wheat exceeded the average yield of the highest yielding durum wheat by 7.7 bushels per acre in the same period.

Milling and baking tests of several of the spring-wheat varieties grown at the Moro substation have been made by the Plant Chemical Laboratory of the Bureau of Chemistry of the United States Department of Agriculture. These tests indicate that most of the varieties are as good as and some are better milling wheats than the Pacific Bluestem, which is the standard spring wheat of the Columbia Basin.

Date-of-seeding experiments with Pacific Bluestem spring wheat indicate that seeding as early in the spring as possible gives the best results.

Rate-of-seeding experiments with the Pacific Bluestem variety indicate that for early spring seeding about 5 pecks per acre is the best rate. For late seeding 3 pecks per acre produced the highest yields.

Of the oat varieties under experiment, the early varieties, like Kherson and Sixty-Day, have given the best results, though Siberian, a variety maturing in midseason, has given yields practically as high as the Sixty-Day and Kherson in a 5-year average.

Forty-two varieties of spring barley have been tested, and 5-year average yields obtained for 13 varieties. The variety giving the highest average yield in the five years was Mariout, C. I. No. 261, a 6-rowed form, yielding 34.3 bushels per acre. The 2-rowed forms White Smyrna and Hannchen produced average yields in the same period of 33 and 32.2 bushels per acre, respectively.

Spring emmer has not given as good results as spring barley or oats.

The grain sorghums have not produced profitable returns. Of the varieties tested, Manchu kaoliang is the most promising.

The 5-year average acre yield in pounds of the highest yielding varieties of the three leading cereals was as follows: Wheat, 1,362 pounds; oats, 1,402 pounds; barley, 1,646 pounds.

Based on the 10-year average farm price of these cereals in Oregon, the acre value of wheat would be $18.39; oats, $19.35; and barley, $20.35.

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