6-1920

Bulletin No. 175 - Sixteen Years of Dry Farm Experiments in Utah

F. S. Harris

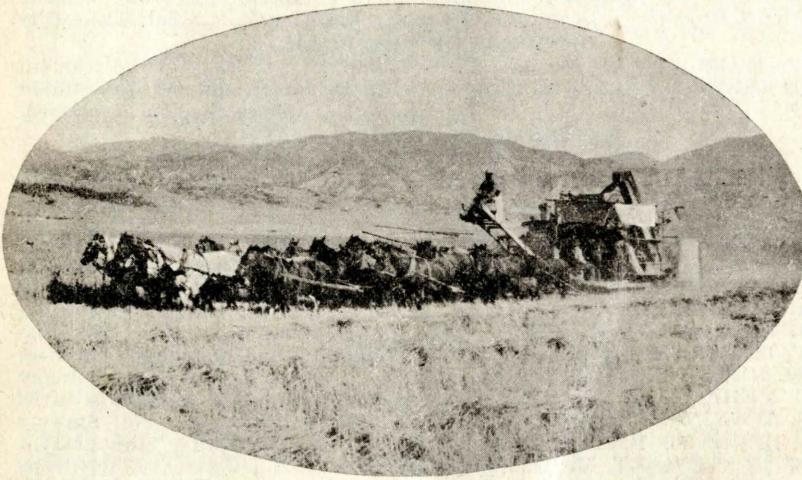
A. F. Bracken

I. J. Jensen

SIXTEEN YEARS OF DRY FARM EXPERIMENTS IN UTAH

By

F. S. HARRIS, A. F. BRACKEN, and I. J. JENSEN



BULLETIN NO. 175

Utah Agricultural College

EXPERIMENT STATION

Logan, Utah **June, 1920**

UTAH AGRICULTURAL EXPERIMENT STATION

EXPERIMENT STATION STAFF

E. G. PETERSON, Ph. D., President of the College

F. S. HARRIS, Ph. D.,	Director and Agronomist
WM. PETERSON, B. S.,	Geologist
H. J. FREDERICK, D. V. M.,	Veterinarian
F. L. WEST, Ph. D.,	Physicist
J. E. GREAVES, Ph. D.,	Chemist and Bacteriologist
W. E. CARROLL, Ph. D.,	Animal Husbandman
BYRON ALDER, B. S.,	Poultryman
GEORGE R. HILL, JR., Ph. D.,	Botanist
O. W. ISRAELSEN, M. S.,	Irrigation and Drainage Engineer
W. W. HENDERSON, M. S. A.,	Entomologist
M. C. MERRILL, Ph. D.,	Horticulturist
D. S. JENNINGS, Ph. D.,	Soil Surveys
R. J. BECRAFT, B. S.,	Range Management
GEORGE STEWART, M. S.,	Field Crops
R. L. HILL, Ph. D.,	Human Nutrition
E. B. BROSSARD, Ph. D.,	Farm Management
GEORGE B. CAINE, M. A.,	Dairying
C. T. HIRST, M. S.,	Associate Chemist
WILLARD GARDNER, Ph. D.,	Associate Physicist
B. L. RICHARDS, Ph. D.,	Associate Botanist
BLANCHE COOPER, B. S.,	Associate in Human Nutrition
EZRA G. CARTER, M. S.,	Associate Bacteriologist
M. D. THOMAS, B. S., B. Sc.,	Associate Agronomist
D. W. PITTMAN, M. S.,	Assistant Agronomist
T. H. ABELL, M. S.,	Assistant Horticulturist
YEPPA LUND, B. S.,	Assistant in Chemistry and Bacteriology
I. J. JENSEN, B. S.,	Assistant Agronomist
L. F. NUFFER, B. S.,	Assistant Botanist
ARTHUR FIFE, B. S.,	Assistant in Irrigation
N. E. EDLEFSEN, B. S.,	Assistant Physicist
SCOTT EWING, B. S.,	Assistant Physicist
G. E. KING, B. S.,	Assistant Entomologist
A. L. WILSON, B. S.,	Superintendent Davis County Farm
PETER NELSON, B. S.,	Farm Superintendent
J. R. BATEMAN, B. S.,	Superintendent Panguitch Farm
HERBERT J. PACK, B. S.,	Assistant Entomologist
BLANCHE CONDIT PITTMAN, A. B.,	Clerk and Librarian
K. B. SAULS, B. S.,	Secretary to the Director

IN CHARGE OF CO-OPERATIVE INVESTIGATIONS WITH U. S. DEPARTMENT OF AGRICULTURE

L. M. WINSOR, B. S.,	Irrigation Engineer
A. F. BRACKEN, B. S.,	Assistant Agronomist

SIXTEEN YEARS OF DRY-FARM EXPERIMENTS IN UTAH

By
F. S. HARRIS, A. F. BRACKEN, and I. J. JENSEN*

The demand for reliable information on dry-farming is increasing every year. As the area that is being cropped by dry-farm methods extends to less favorable regions, it becomes necessary to utilize the most effective methods of culture. In choice dry-farm sections crops may be produced without special care; but when an attempt is made to farm where the rainfall is low or where other conditions are not favorable, it becomes necessary to use every possible means of moisture conservation in order to get satisfactory yields.

Since the demand for information is so insistent, it seems desirable at this time to publish a summary of the important practical results that have been obtained up to date on the state experimental dry-farms. No attempt has been made to present all the data that have been obtained. Only the more practical experiments are summarized.

HISTORICAL

Very soon after Utah was settled it became apparent that much more land suited to crop production was available than could be irrigated with the existing water supply. This led farmers to try growing crops on land above the ditches. Many of the early attempts failed, but by the early 70's dry-farm crops were being successfully produced in many parts of the state.

Early dry-farming was very uncertain because no one was familiar with methods of moisture conservation and with crops adapted to dry-land farming. As the years passed, however, a few farmers developed practices that made their dry-farms almost as profitable as the irrigated lands. By 1900 the interest in the subject had become so widespread that the Experiment Station was being constantly called on for information as to

*Most of the work reported in this bulletin was carried on at Nephi in cooperation with the Office of Cereal Investigations, U. S. Department of Agriculture. The authors wish to acknowledge their indebtedness to the many men who have contributed to the work. F. D. Farrell, P. V. Cardon, A. D. Ellison, and J. W. Jones were all superintendents of the Nephi Substation. Each one gave faithful attention to the experiments during the time he was in charge of them. The foremen of the various experimental farms are to be commended for their unselfish devotion to the work. Mr. N. I. Butt deserves special mention for his assistance in tabulating experimental results. Mr. C. W. Warburton and Prof. George Stewart read the manuscript and gave many valuable suggestions.

methods of raising dry-farm crops. Unfortunately, no reliable information was available. The only knowledge that could be drawn on was the experience of a few successful dry-farmers.

By 1903 the need for exact information on the possibilities and methods of dry-farming became so insistent that the state legislature provided for the establishment and operation of experimental dry-farms in various parts of the state. In accordance with this act, six farms were selected by Dr. John A. Widtsoe, Director, and Professor Lewis A. Merrill, Agronomist, of the Utah Experiment Station, and Mr. George C. Whitmore of the Board of Trustees of the Agricultural College.

These farms were located as follows:

Iron County Farm—four miles west of Parowan.

Juab County Farm—about five miles south of Nephi.

San Juan County Farm—about six miles south of Monticello, near Verdure.

Sevier County Farm—In Grass Valley, about eighteen miles southeast of Richfield, near Burrville.

Tooele County Farm—about fourteen miles south of Grantsville and ten miles west of Tooele.

Washington County Farm—at Enterprise.

Each farm contained forty acres. Further details regarding outlines of experiments and personnel in charge of the work are recorded in Utah Station Bulletin No. 112.

Of the original locations, only the Juab County farm is still being operated for experimental purposes. The others were discontinued because they had either demonstrated the success or failure of dry-farming in the respective regions. In some cases the difficulty of securing proper supervision made it necessary to abandon the farms.

Since the establishment of the original farms, others have been added and some of the latter have been discontinued while others are still bing operated. The Experiment Station dry-farms now active are located at Cedar City, Iron County; Kanab, Kane County; Widtsoe, Garfield County; and Nephi, Juab County. The last was increased to 100 acres and the work is done in cooperation with the Office of Cereal Investigations, U. S. Department of Agriculture. This cooperation has been in effect since 1907.

At the time the Sevier, Tooele, and Iron County Farms were discontinued in 1910, a five-acre farm was established at Ajax, Tooele County, to test shad-scale land and another in Cedar Valley to test greasewood land. Neither of these farms was successful, both being discontinued largely because of the difficulty of securing adequate supervision.

By 1915 irrigataion water had been made available for most of the land at Enterprise, so the equipment was transferred to a farm near Cedar City where the Branch Agricultural College could supervise the work.

The San Juan County farm was discontinued in 1916. It had by this time demonstrated the adaptability of the region to dry-farming, but the inaccessibility of the farm made it impractical to carry on detailed experiments such as are conducted at Nephi.

Since 1914 two more farms have been established—one at Kanab, Kane County, in 1914, and the other at Widtsoe, Garfield County, in 1917. These stations were located to determine the adaptability of the respective sections for dry-farming.

SOIL AND CLIMATE

Every dry-farm section has certain soil and climatic factors which limit in a measure the production of crops. Poor soil is sometimes a limiting factor, but more often unfavorable climatic conditions, such as extremes of temperature and low rainfall limit crop growth. In order properly to interpret the data given in this bulletin a summary of both of these factors will be given as far as possible for each dry-farm station.

SOIL

Physical Composition.—In physical composition the soils of the different sections in which the stations were located vary considerably from gravelly loams to clays and in geological derivation from adjacent mountain weatherings to lake fillings.

The soil on which the Nephi substation is located has been derived from the weathering of adjacent mountain ranges which contain large deposits of limestone and gypsum and deposits of potassium. These soils are just beyond the extension of the Utah Bay of old Lake Bonneville. In physical composition they are clay loams.

Likewise the soils of Iron County were not deposited in connection with Lake Bonneville but were derived from the adjacent mountains.

The sandy loam soils of the San Juan section which were weathered from shales and limestone rich in gypsum are uniform to a considerable depth. The farming section lies in the high plateau region in the southeastern part of the state to the east of the Colorado River.

The Sevier County farm was located on a coarse, sandy loam soil bearing considerable gravel. This soil was eroded and carried from the nearby mountains.

The Tooele experimental farm soil was at one time covered by Lake Bonneville. Wave action on the alluvial slopes of the mountains contributed to the soil formation. These soils are sandy loams.

The Washington County farm, situated on the north slope of the Great Basin leading down into the Escalante Bay of Lake Bonneville, is located on a distinctly sandy soil.

Chemical Composition.—The following data taken from the Utah Experiment Station Bulletin No. 122 give the chemical composition of the soils on which the several substations were and are located:

Table I. Chemical Composition of the Soil from Six Experimental Dry-farms in Utah.

Composition	County					
	Juab	San Juan	Sevier	Iron	Tooele	Washington
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Phosphoric Acid (P_2O_5)	0.419	0.24	0.26	0.23	0.31	0.24
Potash (K_2O)	1.31	0.83	0.83	0.55	0.95	0.87
Nitrogen (N)	0.116	0.065	0.089	0.057	0.07	0.091
Humus	1.54	1.49	1.45	1.09	1.16	1.63
Calcium Oxide (CaO)	4.27	0.56	1.34	18.97	2.15	3.01
Magnesia (MgO)	1.82	0.75	0.42	2.24	0.47	1.06
Carbon Dioxide (CO_2)	2.16	0.20	0.62	18.55	1.01	1.96

An examination of these data indicates that the soil fertility problem in the Great Basin centers on the organic matter not only for the purpose of adding nitrogen but also for liberating other plant-foods.

CLIMATE

Rainfall, evaporation, wind, and temperature all need consideration in a detailed study of climate, but in the arid west rainfall is by far the most important, as it is usually the limiting factor in plant growth.

Precipitation.—High yields of grain are usually associated with high yearly rainfall, but the total amount during a year is not the only point to be considered; distribution is also important. With 40 per cent of the average yearly precipitation

Table II. Elevation in Feet and Average Rainfall for Each Month for Each Dry-farm Station Established by the State of Utah.

Station	County	Elevation (feet)	Years of Record	Months and Average Precipitation												Total
				Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec	
Parowan	Iron	5,970	25	1.02	1.35	1.59	1.13	1.04	0.31	1.23	1.42	1.15	0.92	0.73	0.95	12.84
Nephi (near)	Juab	6,000	21	1.22	1.26	1.61	1.31	1.76	0.60	0.67	0.87	0.97	1.16	0.92	1.03	13.32
Monticello	San Juan	7,050	12	1.37	1.98	2.06	0.99	0.85	0.70	1.88	1.55	1.76	2.04	1.30	1.57	18.05
Burrville	Sevier	6,800	5	0.93	1.27	0.54	1.29	0.58	0.98	1.20	0.57	0.91	0.76	0.89	0.64	10.56
Tooele	Tooele	4,900	20	1.29	1.43	2.11	1.86	2.23	0.93	0.70	0.88	1.05	1.48	1.45	1.02	16.43
Enterprise	Washington	4,270	11	3.16	2.04	2.04	1.26	0.73	0.53	1.30	1.42	1.48	1.05	1.14	0.95	17.10
Cedar City	Iron	5,750	12	0.84	1.01	1.09	1.21	0.86	0.46	1.38	0.94	1.34	1.20	1.17	0.84	12.34
Kanab	Kane	4,925	12	1.53	1.36	2.17	1.19	0.86	0.43	1.18	1.08	0.99	0.82	1.32	0.87	13.80
Winder (near Widtsoe)	Garfield	7,000	3	0.98	0.71	1.20	1.64	0.84	0.66	1.59	1.52	0.80	T.	1.12	0.54	11.60

falling during April, May, and June, good crops may usually be expected in Utah. Table II gives the rainfall on or near the dry-farm stations.

Evaporation.—The only evaporation observations on the experimental dry-farms are those made at Nephi where these data have been taken for the last twelve years from April 1 to October 31, inclusive. The average monthly and average total inches evaporated follows:

Table III. Evaporation from a Free-water Surface at Nephi from April to October, Inclusive.

(Average of 12 years)

Average Monthly Evaporation (inches)							Total Evaporation (inches)
April	May	June	July	August	September	October	
4.282	6.847	8.747	9.381	9.103	6.290	3.518	47.265

In dry-farm sections economical crop production demands that the soil not only be in a condition to absorb moisture readily but also to retain it. At Nephi the average evaporation from a free water surface exceeds the average precipitation by three and one-half times, and evaporation is probably as great at all other stations. This comparatively high evaporation is due to the large proportion of sunshine, the low humidity, and moderate winds.

Temperature.—The temperature during the growing season is sufficiently high to produce successful crops at the several experimental dry-farms, but often the spring and fall frosts do damage. The following table gives the more important temperature data concerned with dry-farming:

Table IV. Frost Dates and Length of Growing Season.

Station	Record in Years	Average Last in Spring	Average First in Fall	Average Length of Growing Season	Absolute Latest in Spring	Absolute Earliest in Fall
Parowan	27	May 29	Sept. 27	121	July 3	Sept. 5
Nephi	23	May 29	Sept. 28	123	June 25	Sept. 12
Monticello	10	May 26	Sept. 3	127	June 26	Sept. 12
Richfield	23	June 1	Sept. 18	109	July 9	Aug. 26
Tooele	22	May 11	Oct. 10	152	June 15	Sept. 14
Cedar City	13	May 12	Sept. 26	136	May 28	Sept. 6
Kanab	10	May 27	Sept. 30	126	June 26	Sept. 14

Wind.—Nephi is the only dry-farm station at which wind data have been taken. The average daily wind from April 1 to October 31, inclusive, has been 94.68 miles, or an average velocity per hour of 4.07 miles. Winds very seldom cause any damage in Utah.

PRACTICAL APPLICATION OF RESULTS

In considering the principal results of this bulletin, it should be kept in mind that sections differing in soil, rainfall, or other conditions from those at Nephi may get results contrary to those herein presented, although for the most part the conclusions drawn here are of general application. With lighter soils and heavier rainfall the kind and variety of crops best adapted may vary somewhat. Because reports from other parts of the arid region show essentially the same results as at Nephi, the data from the cultural methods are thought to be of more general application than varietal or crop tests which depend more on soil and climatic conditions.

RESULTS FROM THE NEPHI SUBSTATION

The experimental work at the Nephi Substation is now divided into seven major projects including (1) cropping systems with winter wheat; (2) tillage methods with winter wheat; (3) rotations with winter wheat, winter barley, spring oats, peas, potatoes, and corn; (4) varietal tests of winter and spring wheats, oats, barleys, spelt, and emmer, and of peas, beans, corn, and potatoes; (5) fertility tests with barnyard and green manure; (6) breeding work with winter wheats, winter barley and oats; and (7) a forage crop test. Besides these experiments, a number of miscellaneous tests have been discontinued because they were unimportant or because the problem was satisfactorily completed. Of the above experiments only the cropping systems and tillage methods, together with a consideration of crops adapted to dry-farming, will be discussed in this bulletin.

CROPS ADAPTED TO DRY-FARMING

During the last sixteen years numerous tests have been conducted at the Nephi substation to determine which crops can be grown profitably on the dry-lands. With our low yearly rainfall, moisture, especially its distribution through the growing season, is usually the limiting factor in plant growth. At Nephi under a system of alternate fallow and cropping the seasonal distribution is not so important as where this system is not used. Even when cropped in this way, highest yields are associated with highest seasonal precipitation, the most favorable results obtaining when about 40 per cent of the rainfall comes during April, May, and June. Because weather conditions are so often unfavorable the number of crops which can be grown successfully is limited. A factor further limiting the crops which are adapted to dry-land conditions is the necessity that the land lie fallow one year after every one or two crops. A discussion of crops tested at the Nephi substation for the last sixteen years follows. Forage crops are of only minor importance.

Forage Crops.—Until the tractor can perform all the operations on a dry-farm, forage will be needed to feed work animals. Often dry-farms are located several miles from the irrigated lands and where it becomes necessary to haul hay from one to the other considerable time is lost, frequently at a season when farm work is most urgent. Even a low yield of forage may in such cases be economical.

The adaptability of the following crops to dry-land conditions has been tested: alfalfa, sweet clover, corn, peas, vetch, brome-grass, tall meadow oat-grass, Sudan-grass, millet, grain sorghums, rape, and various mixtures of these crops together with a number of other forages not important enough to mention.

Native Vegetation.—The Levan Ridge on which the station is located was at one time covered with a native wheat grass locally called "blue-grass" (*Agropyron occidentalis*). In seasons of high rainfall this grass grew so thrifty that it was at times cut for hay. Over-grazing by sheep so reduced the stand, however, that sagebrush (*Artemesia tridentata*) finally took the place of this forage, and at the time the station was established in 1903 the entire ridge was covered by brush.

Alfalfa.—Alfalfa has been grown on the station farm in

Table V. Yield of Alfalfa in pounds per acre at the Nephi Substation from 1905 to 1919, Inclusive.

Year	Yield (lbs.)
1905	2375
1906	2850
1907	1650
1908	1910
1909	2775
1910	0
1911	0
1912	1820
1913	1745
1914	3010
1915	2690
1916	1995
1917	2522
1918	2835
1919	1524
Average	1980

varietal, cultural, and cropping tests since 1904. In years of severe drouth the yield has been low, but in seasons with normal precipitation fair results have been secured.

The yields of alfalfa from 1905 to 1915, inclusive, shown in Table V, were obtained from a single fifth-acre plat; from 1916 to 1919, inclusive, the yields are averages from five tenth-acre plats. The failures for 1910 and 1911 were due to late spring frosts and drouth in connection with an old stand of alfalfa. The year 1919 brought a similar condition of severe drouth together with freezing temperatures when the alfalfa was well advanced in its growth. Under these conditions fair yields of alfalfa were obtained from plats where the alfalfa was only two and three years of age, while old stands were failures. The average yield of this test, 1980 pounds, covering a period of fifteen years should be sufficient to interest dry-farmers.

To produce a good stand of alfalfa more care should be used in preparing the seed-bed and in sowing than is ordinarily needed for the cereals. Fall-plowing preceding liberal spring cultivation to make a uniform compact seed-beed is the first requisite. Good stands are obtained only when the soil contains sufficient moisture to insure germination and when the temperature is such that a vigorous growth is possible. Usually the best results are obtained by seeding during the first part of May. The rate of sowing alfalfa depends upon the condition of the soil, but usually six to eight pounds per acre is sufficient. The depth of seeding should not be more than one and a half inches—better one inch. This shallow sowing demands a firm seed-bed with moisture very near the surface. Alfalfa seeded with the grass-seed attachment of a grain drill is preferable, although the wheat openings of the drill partly plugged with reducers may serve where only a small acreage is to be sown. Sowing a nurse crop with alfalfa has not been successful under dry-land conditions except in seasons of high May and June rainfall.

The care of dry-land alfalfa is of considerable importance. Cultivation with a spring-tooth or spike-tooth harrow before growth starts in the spring, and after it has stopped growth in the fall is advisable. This cultivation not only retards evaporation and allows moisture to enter more readily but also reduces damage by alfalfa weevil if the crop is troubled with this pest.

Sweet Clover.—Sweet clover was first seeded at the station in 1914, but due to slowness in growth the yield was not sufficient to justify harvesting.

The yield of sweet clover produced in 1915 was exceptional. When the yields in 1916, 1917, and 1918 are compared with those of alfalfa during these years it is shown that the alfalfa gave the larger returns. On exceptionally heavy soils sweet clover is likely to yield better than alfalfa, but where the soil is of ordinary quality there is but little difference. Even though the difference in yield between the two crops is small, alfalfa has a n .mber of advantages over sweet clover such as its superior palatability and perennial habit of growth which make it preferable.

The discussion of seed-bed preparation and method and rate of seeding given for alfalfa applies for sweet clover.

Table VI. Yields of Sweet Clover from 1915 to 1918, Inclusive, at the Nephi Substation.

Year	Yield per acre (pounds)
1915	4138
1916	1258
1917	2036
1918	1790
Average	2305

Corn.—Since the station was established in 1903 corn has been grown in various cultural, varietal, and rotation tests.

The yields of corn fodder given in Table VII for 1904, 1905, and 1906 are the result of averages from nine fifth-acre plats. The results from 1915 to 1919, inclusive, are yields from a single tenth-acre plat.

Table VII. Yields of Corn Fodder at the Nephi Substation on Plats Alternately Cropped and Fallow.

Year	Yield per Acre (pounds)
1904	1210
1905	405
1906	1105
1915	1670
1916	590
1917	1640
1918	730
1919	0
Average	919

Table VIII. Average Yields of Corn Fodder from Duplicate Plats Continuously Cropped from 1915 to 1919, Inclusive, at the Nephi Substation.

Year	Yield per Acre (pounds)
1915	919
1916	629
1917	1000
1918	2323
1919	0
Average	974

Table IX. Yields of Corn Fodder, and Wheat in an Alternate Rotation with Yield of Wheat after Corn Compared with Wheat after Fallow Covering a Period of Twelve Years. Single Tenth Acre Plats at the Nephi Substation.

Crop	Years Tested and Yields in Pounds and Bushels												Average
	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	
Corn after Wheat (pounds)	1855	1240	40	40	1420	750	3310	2070	370	1360	750	0	1100
Wheat after Corn	25.8	6.5	19.3	28.5	18.8	4.4	41.6	35.0	17.2	28.0	16.2	8.7	20.8
Wheat after Fallow	27.5	4.6	13.7	30.0	14.7	2.0	39.3	44.8	23.5	28.2	16.3	12.8	21.5

Table X. Results Covering a Period of Twelve Years from 1908 to 1919, Inclusive, Showing Yield of Peas after Fallow and after Wheat, and Yield of Wheat after Fallow and after Peas on Single Tenth-acre Plats at the Nephi Substation.

Crop	Years Tested and Yields in Pounds and Bushels per Acre.												Average
	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	
Peas after Wheat (pounds)	1080	1050	35	0	315	115	180	840	660	740	570	0	465
Wheat after Peas (bushels)	30.1	2.2	18.3	29.5	17.8	4.2	41.3	41.8	17.5	24.2	16.0	8.7	21.0
Wheat after Fallow (bushels)	27.5	4.6	13.7	30.0	14.7	2.0	39.3	44.8	23.5	28.2	16.3	12.8	21.5
Peas after Fallow (pounds)								348	580	1080	1170	0	792

Corn is not grown extensively on the dry-lands of Utah because it has failed to produce satisfactory yields except in seasons of high rainfall. The results given in Tables VII, VIII, and IX all give proof of this statement.

For corn, fall plowing previous to disking and harrowing in early spring is the best practice. The time of seeding depends upon spring frosts; usually seeding is delayed until such danger is past, May 10 being the approximate date at Nephi. A corn planter is the most efficient implement for sowing, but an ordinary grain drill with part of the spouts stopped may be used. The rate of seeding can be regulated as desired. If the stand is too thick some of the plants can be thinned out. The rows should be about forty inches apart to allow frequent cultivation and hoeings to prevent weed growth.

The yields of wheat following corn in rotation were secured by double disking and harrowing the corn land before seeding the winter wheat. The wheat land was fall plowed for corn.

Peas.—Peas have been grown at the Nephi substation since 1904, but no definite tests were started until 1908. Since that year peas have appeared in a regular rotation alternating with wheat. Varietal tests have also been attempted.

The yield of peas grown either in rotation with wheat or alternating with fallow has not been sufficient to justify considering this as a good forage crop for dry-lands. Either the Canada or Carleton field pea is best for forage.

The pea land from which the yields recorded in Table X were taken was given the same treatment as the corn land after the crop was removed. The soil was double disked, harrowed, and seeded to winter wheat. The wheat land was fall plowed for peas.

The rotations given in Table X are so planned that yields following each treatment are given every year. While one plat produces a crop of wheat another is fallow; the next year the fallow plat grows the crop and the wheat plat is fallow. The same system is followed for the other rotations.

Perennial Grasses.—Of all perennial grasses tested at Nephi, smooth brome-grass (*Bromus inermis*) has proved the best. After the second year, however, the stand became thin, bunchy, and sod-bound. Tall meadow oat-grass made a satisfactory growth, the main objection to it being that at an early stage in its growth the grass became so wiry and tough that stock did not relish it. At present there is no perennial grass that can be generally recommended for Utah dry-lands.

Rye.—Rye should not be overlooked as a forage and pasture crop on western dry-lands. This cereal in mixtures with other grains is now being tested at the station as a forage. The first results will appear in 1920. It is common knowledge in certain sections of Utah that rye makes an excellent early pasture crop. Horses and cattle apparently are very fond of the tender plants when in the early stages of growth. Rye at present is grown mostly on land which will not produce good crops of wheat, and in sections where the rainfall is not sufficient to give profitable yields of other cereals. The small amount of labor necessary for growing rye often makes it profitable to turn cattle in the fields as soon as the plants are large enough to pasture and keep the stock there until ready for market in June and July. Otherwise undesirable land can often in this way be made to yield a profit. The rye is sown in the fall on land plowed and harrowed the previous spring. If pastured until June enough seed will then mature to produce a stand if the land is double disked the following autumn. This may usually be repeated satisfactorily for two or more years, depending on the quantity of seed which is produced.

Miscellaneous Forage Crops.—A number of miscellaneous forage crops, such as vetch, millet, grain sorghums, kafir corn, rape, soybeans, mangels, red clover, alsike clover, and a number of others, have been tested for their adaptation to dry-land farming, but none have proved as successful as alfalfa, sweet clover, or corn.

Grain Crops.—It is doubtful if the grains will ever be replaced by any other crop on the dry-lands. The winter varieties are so adapted in their resistance to severe weather conditions that it is possible to sow them in the fall on fallow land and have them appear the following spring with a root system sufficiently developed to take advantage of early spring moisture. And even though seeding is delayed until spring either because the fall varieties cannot stand the severity of the winter or because of poor fall conditions for sowing, there are spring varieties that will give profitable yields in normal seasons.

Considerable well-directed attention has been given the grain crops during recent years. Reforms in tillage operations and cropping systems together with improvements due to government and state investigations have all helped to increase yields. Rust-resistant types of wheat have been selected, and high yielding drouth-resistant strains have been increased when found.

To determine their adaptability to dry-land conditions, the following grain crops have been tested during the last sixteen years at the Nephi substation: wheat, both spring and winter;

barley, winter and spring; oats, winter and spring; emmer; spelt; peas; and beans.

Wheat.—For the dry-farms, wheat is the most valuable of all crops. This is true not only because of its superior adaptability to an alternate system of cropping and fallowing but also because of its high value per unit of bulk and great resistance to severe climatic conditions.

Fig. 1.—Nursery where dry-farm crops are being improved, Nephi.

Wheat has been grown in varietal, tillage, cropping, and rotation tests at the Nephi substation since 1904. In the varietal trials over sixty winter wheats and more than twenty spring varieties have been tested. Only eleven winter, twelve common spring, and six durum varieties have proved suitable for continued trials.

In Table XI is given the yields produced by eleven winter wheats tested between the years 1904 and 1919, inclusive. Beloglina C. I. No. 1544*, was first with an average yield of 26.7 bushels per acre, closely followed by Crimean C. I. No. 1437 and Turkey C. I. No. 2998, all red winter wheats. The fact that Beloglina was not raised during some of the poorer years ac-

*C. I. No. refers to the Cereal Investigations number given to each variety by the U. S. Department of Agriculture, Bureau of Plant Industry, Office of Cereal Investigations.

Table XI. Yields in Bushels per Acre of Eleven Winter Wheat Varieties Tested at the Nephi Substation Between the Years 1904 and 1919, Inclusive. Test from 1904 to 1907, Inclusive, on Single Fifth-acre Plats; from 1908 to 1916, Inclusive, on Duplicate Tenth-acre Plats; from 1917 to 1919, Inclusive, on Triplicate Tewntieth-acre Plats.

Variety	C. I. No.	Years Tested and Yields in Bushels per Acre																Average	Relative yield for years grown based on Turkey as 100
		1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919		
Beloglina..	1544			31.9	30.0	33.3							49.5	11.5	19.2	23.3	15.2	26.7	102
Crimean ..	1437					30.3	18.6	20.3	26.7	19.5	.10.5	40.0	29.4	23.0	20.0	15.3	14.1	22.3	112
Turkey	2998	23.8	16.9	33.5	37.7	35.0	16.2	15.8	21.4	22.1	11.3	43.0	28.0	10.3	19.7	5.4	11.7	22.0	100
Bulgarian	2048					32.5	13.0	7.8	31.2	22.8	12.2	35.9	34.5	19.7	17.9	15.5	15.6	21.5	108
Alberta Red......	2979					34.3	14.3	12.8	24.2	19.7	8.3	35.0	36.5	10.2	19.5	22.3	16.5	21.1	106
Armavir..	1355					28.3	21.3	14.0	21.0	22.3	10.3	35.5	32.5	13.0	19.1	15.3	15.3	20.6	103
Kharkov..	1442					26.2	19.2	17.0	27.2	19.8	7.0	37.7	27.9	9.3	18.3	21.0	14.4	20.4	102
Ghirka Winter..	1438					27.6	15.6	12.2	29.5	22.1	11.7	34.1	29.7	9.9	20.1	9.9	16.6	19.9	99
Kofod	2997	18.9	2.6	32.5	38.2	24.3	2.5	.8	32.7	7.8	1.9	42.5	23.8	21.3	16.6	8.3	13.4	18.0	82
Gold Coin	2996	22.5	1.5	20.4	29.5	27.6	17.0	10.7	21.2	10.1					20.7	2.2	11.4	16.2	75
Odessa	3274	20.5	11.5	24.0	27.1		11.2	10.0	24.2					2.5	18.9	10.2	16.8	16.1	94

counts in part for its being at the head of the list. Crimean is the real leader.

For fall wheats the safest cropping system under all conditions has been that of alternate cropping and fallow. The one essential feature in case of fallow after either fall or spring plowing is weed control. It is better to grow a second crop of wheat than a crop of weeds.

The time of seeding fall wheat depends in a measure on the moisture in the soil, this date extending from September 15 to October 15. The early sowings have been best where the soil was in condition to insure proper germination and growth.

From 1914 to 1916, inclusive, the varieties of spring wheats shown in Table XII were grown on duplicate tenth-acre plats; from 1917 to 1919, inclusive, on duplicate twentieth-acre plats.

Spring wheats including a few durums have been grown at the station since its beginning, but all of the varieties grown before 1914 were eliminated because higher yielding varieties were introduced.

Table XII. Annual and Average Yields in Bushels per Acre of 18 Spring Varieties of Wheat Tested at the Nephi Substation Between 1914 and 1919, Inclusive.

Variety	C.I. No.	Yields in Bushels and Years Tested						Average	Relative yield for years grown based on Ghirka as 100
		1914	1915	1916	1917	1918	1919		
Common									
Chul	2227				18.3	15.0	6.8	13.4	156
Saumur	2346				17.6	13.6	6.9	12.7	149
Early Baart	1697				16.1	13.6	3.6	11.1	130
Ghirka Spring	1517	11.2	19.0	9.0	12.6	11.0	2.0	10.8	100
Koola	2203				17.0	12.6	3.1	10.9	127
Reg. Defiance	5543			14.2	9.8	12.7	1.5	9.5	91
Galgalos	2398				14.3	11.5	1.5	9.1	105
Marquis	4158		15.8	7.7	8.5	8.9	2.8	8.7	81
Pacific Bluestem					13.5	10.3	1.6	8.4	99
Little Club	4066				11.1	12.4	1.3	8.3	97
Defiance	5542			5.3	13.8	10.5	2.1	7.9	91
Dicklow	3663				11.3	8.8	1.5	7.2	84
Durum									
Kubanka	1440	15.7	18.2	15.0	7.8	12.3	2.5	11.9	110
Adjini	1594	19.0	15.3	12.7	9.3	12.2	1.8	11.7	108
Mohamed Ben Bachir	2087	18.5	14.2	14.2	8.6	12.2	1.7	11.6	107
Velvet Don	2247	17.2	12.8	14.6	8.7	11.8	2.5	11.2	104
Arnautka	1494	15.0	14.2	14.0	8.6	11.5	2.3	10.9	100
Pelissier	1584	12.7	17.0	9.3	10.6	11.0	1.8	10.4	99

An examination of Table XII will show that Chul and Saumur, wheats of rather inferior quality, have been the highest yielding varieties. Early Baart, a soft white wheat, now becoming very popular in the west, because of good quality and high yielding power, was third in yield. Marquis, a widely grown hard red spring wheat, ranks eighth. Hard Federation, a recent introduction at the Nephi Substation, does not appear in the table, but from results obtained at other western stations this wheat promises to become of great value where spring seeding is necessary.

The yields of the durum varieties given in the last part of Table XII compare very well with the common spring varieties. Kubanka, credited with the highest yield of 11.9 bushels, was very closely followed by Adjini, Mohamed Ben Bachir, and Velvet Don. A comparison between Tables XI and XII quite conclusively indicates that where possible winter wheat should be sown in preference to the spring varieties.

Barley.—Barley has been grown at the Nephi Substation since 1904, but practically all varieties grown before 1914 were eliminated either by almost continuous failure or by very low yields. The varieties introduced in 1914 have proved of considerable value. Table XIII, which contains the yearly average yield of each variety of winter and spring barley grown in the regular alternate cropping system indicates that this crop deserves consideration by dry-farmers.

Table XIII. Annual and Average Yields of Winter and Spring Barleys Grown at the Nephi Substation on Duplicate Tenth-Acre Plats, 1914 and 1915, from 1916 to 1919, inclusive, on Triplicate Twentieth-acre Plats.

Variety	C. I. No.	Years Tested and Yields in Bushels per Acre						Average
		1914	1915	1916	1917	1918	1919	
Winter								
Bulgarian	521	59.0	49.6	13.8	24.3	36.5	18.6	33.6
Turkestan	711	61.7	50.2	7.9	25.1	30.4	14.3	33.2
Tennessee	257	50.9	43.5	8.1	21.7	26.0	13.6	27.3
Utah Winter	592	39.8	53.5	12.2	16.7	20.1	13.6	26.0
Spring								
White Smyrna	195		29.5	16.8	23.8	11.9	7.3	17.9
Coast	690		27.3	13.7	19.0	16.7	6.2	16.6

The four winter barleys now in the test are not only winter-hardy but also drouth-resistant. Comparing the average yields of barley during the years tested with that of wheat from 1915 to 1919, inclusive, shows 1370 pounds per acre for the Bulgarian barley and 1425 pounds for the Beloglina wheat. The yield of the two spring barley varieties shown in Table XIII was not sufficient to warrant seeding except in case of winter-killing of the fall varieties. The tillage and method of cropping for barley are similar to wheat.

Oats.—Oats have been grown at the Nephi Substation since 1904, but a varietal test of spring varieties was not started until 1909 and for fall oats until 1915.

The winter oats have been grown with various degrees of success. The year 1915, as indicated by Table XIV, was favorable for this cereal, and 1916 was poor. Failure in 1919 was due to winter-killing. The development of a winter-hardy oat variety would help popularize this grain. Boswell winter has given most satisfaction at Nephi. The average yields of the spring oat varieties with Big Four standing first are equal to yields produced by the winter varieties.

Comparing the average yields produced by oats with those of barley the difference is decidedly in favor of barley. The yields of the oat varieties given in Table XIV were secured from a system of alternate cropping and fallowing.

Peas and Beans.—As a grain to be grown on dry-lands every season neither peas nor beans has shown promise. The farmer, however, has an excellent opportunity to make profitable returns from both or either of these intertilled crops by growing them during seasons of high spring rainfall. Peas require early sowing which makes it difficult to decide whether the rainfall is ample. But even with peas a high rainfall preceding April 20, the usual time for sowing, would give assurance of profitable results. Because of early spring frosts beans cannot be sown safely as early as peas. Usually by May 10 to 15, when bean-sowing begins, it may be predicted with fair assurance that the crop will succeed or fail, depending on the seasonal rainfall before these dates.

On the Nephi Substation peas have given yields varying from 5 to 12 bushels and beans from 3 to 8 bushels of seed in favorable seasons. The Kaiser, Early Britain, and Carleton field pea varities have given best results; for beans the Utah pea bean was best.

In Tables IX and X it is seen that with intertilled crops appearing in rotation with wheat, the yield of peas for forage would not be profitable except in replacing fallow. The yield of wheat is almost as large after peas as after fallow. This fact makes it possible to replace the fallow with either peas or beans without fear of greatly reducing the yield of wheat. Seeding either of these crops should be preceded by fall plowing followed

Table XIV. Annual and Average Yields of Spring and Winter Oat Varieties Grown at the Nephi Substation on Single Tenth-acre Plats before 1916, from 1916 to 1919, inclusive, on Duplicate Twentieth-acre Plats.

Variety	C. I. No.	Years Tested and Average Yields in Bushels											Average	Relative yield for years grown based on Swedish Select as 100
		1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919		
Spring														
Big Four							28.4	40.6	14.4	8.7	24.4	4.1	20.1	99
Black American	549	15.6	8.4	11.6	25.3	13.5	29.4	42.5	16.9	14.7	27.7	5.0	19.1	111
New Roosevelt	752			11.3	26.6	11.6	35.0	30.3	15.9	2.8	25.2	5.3	18.2	98
Swedish Select	134	15.3	6.2	8.8	24.1	13.1	30.7	39.1	15.8	8.6	23.1	4.4	17.2	100
Sixty Day	165	15.0	2.8	2.8	15.3	6.3	30.6	36.1	10.6	19.4	18.6	5.6	14.8	86
Richland	787								16.6	20.0	13.1	4.4	13.5	96
Winter														
Boswell	480							50.6	9.7	20.0	21.0	0	20.3	117
Winter Turf	274							50.0	11.3	17.1	16.6	0	19.0	109
Red Rustproof	518							35.6		9.9	12.7	0	14.5	82
Fulghums	708							35.5	4.3	10.4	13.5	0	12.7	88

Table XV. Annual and Average Yields of Wheat and Potatoes in Alternate Rotation compared with Wheat after Fallow. Tests made on Single Tenth-acre Plats at the Nephi Substation.

Crop	Years Tested and Yields in Bushels												Average
	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	
Potatoes	42.5	48.7	7.3	0	32.4	34.5	51.2	25.7	26.0	23.7	19.2	0	28.1
Wheat after Potatoes	22.6	2.5	17.2	32.1	18.7	4.2	43.0	34.8	18.7	25.0	17.1	5.5	20.1
Wheat after Fallow	27.5	4.6	13.7	30.0	14.7	2.0	39.3	44.8	23.5	28.2	16.3	12.8	21.5

by one or more early spring harrowings. An ordinary grain drill can be used fo seeding by stopping up the spouts that are not needed. The rows for both beans and peas should be at least 36 inches apart to allow for frequent cultivations.

Potatoes.—The production of potatoes on western dry-land may never reach commercial importance. The yields at Nephi, however, have indicated that a sufficient crop can be produced on wheat fallow land to justify the dry-farmer in growing at least enough for family needs.

Although the yield of potatoes given in Table XV, covering the period from 1908 to 1919, inclusive, was low, yet the results show that potatoes can fit into a rotation with wheat without causing a material decrease in the yield of wheat as compared with the usual wheat cropping system. For potatoes the wheat land was fall plowed; the seed-bed preparation of potato land for wheat consisted of one double disking followed by one or more harrowings. The Peerless potato variety was used in this rotation.

During the twelve years from 1908 to 1909, inclusive, the eighteen varieties shown in Table XVI were tested. The yields varied from 124.0 bushels for Willard in 1916 to 4.0 for Early Ohio in 1910. Thoroughbred, introduced into the test in 1913, has given the highest average yield—74.3 bushels per acre. While considerable difference in yield has occurred from year to year with most of the varieties, Thoroughbred has not suffered very severely during any of these seasons. Due to late spring planting of potatoes the farmer again has an opportunity to take advantage of the season. If the spring before about May 10 has been one of considerable rainfall potatoes can usually be planted with fair assurance of profitable returns, but if the spring has been dry low yields would likely follow. Potatoes on the dry-lands should be planted on the lighter or sandy soils if such are available.

CROPPING SYSTEMS FOR WINTER WHEAT

The early history of dry-farming in the West reports numerous crop failures. Some of these failures were due to lack of drouth-resistant varieties; some to improper seed-bed preparation; and others to a lack of knowledge about cropping methods. At present complete failures are rare. The early experiences of the dry-land farmers taught a new system of soil culture: a crop alternating with a clean summer fallow. In the discussion of cropping systems which follows different methods of cropping land to wheat together with a consideration of rotations of wheat with intertilled crops will be given.

Table XVI. Annual and Average Yields of Potato Varieties Grown at the Nephi Substation During the Period from 1908 to 1919, inclusive.

Variety	Years Tested and Yield in Bushels per Acre												Average	Relative yield for years grown based on Irish Cobbler as 100
	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919		
Thoroughbred						48.0	86.0	33.0	88.0	80.0	116.0	69.0	74.3	
Freeman							126.0	40.0	82.0	60.0	38.0	54.0	66.0	109
Idaho Rural							76.4	28.0	82.0	66.0	96.0	40.0	64.7	106
Green Mountain	37.8	118.0	54.0	48.0	21.0	25.0	112.0	20.0	60.0	44.0	70.0	35.0	58.6	112
Pearl					28.0	34.0	108.0	19.0	62.0	52.0	98.0	44.0	55.6	105
Peerless		98.0	36.0	73.6	33.0	45.0	76.4	10.0	70.0	50.0	66.0	51.0	55.4	106
Willard	35.0	74.0	30.0	38.0	37.0	20.0	86.0	5.0	124.0	52.0	98.0	55.0	54.5	105
Early Bird	44.3	106.0	26.0	58.0	17.0	41.0	104.0	17.0	60.0	72.0	90.0	47.0	53.2	102
Irish Cobbler	46.2	112.0	18.0	24.0	33.0	23.0	76.0	24.0	74.0	44.0	54.0	95.0	51.9	100
Rural New Yorker					24.0	35.0	92.0	16.0	46.0	58.0	78.0	65.0	51.7	93
California Russet					29.0	25.0	108.0	18.0	46.0	38.0	54.0	90.0	51.0	92
Acme					15.0	24.0	76.4	11.0	40.0	56.0	74.0	70.0	45.8	82
Early Ohio	32.2	89.0	4.0		37.0	24.0	50.0	13.0	35.0	62.0	64.0	79.0	44.5	90
Early Manistee					17.0	28.0	76.0	10.0	48.0	52.0	68.0	50.0	43.6	78
Maggie Murphy							62.0	6.0	40.0	46.0	50.0	48.0	42.0	65
Early Eureka		58.6	34.0	36.0	26.0	30.0	78.0	7.0	18.0	36.0	28.0	47.0	36.2	70
White Ohio					33.0	22.0	56.0	12.0	21.0	40.0	54.0	43.0	35.1	63
Market Prize							26.0	7.0	46.0	42.0	42.0		32.6	55

At the Nephi Substation one cropping method experiment has been in operation since 1904. To make the test more complete several experimental plats were added in 1915. The original test, which still remains, consists of four fifth-acre plats while the addition is made up of twenty-four tenth-acre plats. The experiment is now so arranged that results for each test are secured every year. Any crop or method of farming must produce a net profit to be efficient. In the discussion of the results this factor has been taken into consideration. The cost of plowing, harrowing, weeding, disking, harvesting, and threshing was determined from contract prices for these operations in the Juab Valley for 1919. The price of land was placed at $60 an acre and interest at 8 per cent; the price of wheat at $2 a bushel. While the expense in producing a crop of wheat and the value of land differ considerably in various sections, yet the relative costs are of value to all dry-farming areas operated under similar conditions.

The yields of this experiment covering a period of sixteen years from 1904 to 1919, inclusive, are contained in Table XVII.

Continuous Cropping.—The continuous cropping test was used as a basis for judging the value of the remaining tests. While the results show no failure, yet in seasons such as 1913 and especially 1919 the low yields would not be considered under practical farm conditions. The total yield during the 16-year period amounted to 187.2 bushels with an average yield per crop and year of 11.7 bushels per acre. The tillage operations preceding the sowing consisted of plowing followed by a double disking and two harrowings. For fall plowing the expense was $3.75 per acre; for spring plowing used in other tests, $3.25, the dry soil in fall requiring more power for plowing. The expense per acre charged to each crop under continuous cropping is as follows:

Plowing	$ 3.75
Disking (double)	1.50
Two harrowings at 50c	1.00
Seeding	1.00
One bushel clean seed at $2.05	2.05
Harvesting	2.00
Threshing 11.7 bushels at 12c	1.40
Hauling 11.7 bushels to market at 4c	.47
Interest on land, $60 per acre at 8%	4.80
Taxes on land	.24
Total Expense	$18.21

Gross returns, 11.7 bushels at $2	$23.40
Net returns	5.19

Alternate Cropping.—The alternate cropping used by the majority of dry-farmers in the West even though expensive has been found safest for all seasons. This test has produced a total yield over the 16-year period of 166.3 bushels with an average yield per crop of 20.8 bushels per acre. To put this method of cropping on a basis of equality with the continuous cropping, the total yield must be divided by the number of years the test has been in operation. The average per year determined in this way is 10.4 bushels per acre. To compare the net returns of this test with the continuous cropping the results for each crop were divided by 2.

In the alternate cr pping test the fallow was spring plowed, immediately followed by one harrowing, one weeding when the weeds had started growth, and another harrowing just before seeding in fall. The expense per acre for one crop follows:

Plowing	$ 3.25
Two harrowings at 50c	1.00
One weeding	1.00
Seeding	1.00
One bushel of clean seed at $2.05	2.05
Harvesting	2.00
Threshing 20.8 bushels at 12c	2.50
Hauling 20.8 bushels to market at 4c	.83
Taxes for two years, the fallow and crop year at 24c	.48
Interest for two years on $60 land at 8%	9.60
Total Expense	$23.71

Gross returns on 20.8 bushels at $2	$41.60
Net returns per crop	17.89
Net returns per year	8.94

Two Crops in Three Years.—In calculating the net returns from this method of cropping the expense covered by one fallow and two crops was considered. Fall plowing, costing 50c more per acre than spring plowing, was given the land whether followed by crop or fallow. Usually considerable volunteer growth follows fall plowing and this demands an extra weeding in addition to that given alternately cropped, spring plowed land. Spring plowing in other tests was delayed until the volunteer and weed growth had started.

The expense per acre for the two crops in three years follows:

Plowing	$ 3.75
Two harrowings of fallow, one in spring and one in fall at 50c	1.00
Two weedings at $1	2.00
Seeding	1.00
One bushel of seed at $2.05	2.05
Taxes on land	.24
Interest on $60 land at 8%	4.80

End of Fallow Year

Harvesting	2.00
Threshing 18.4 bushels at 12c	2.21
Hauling 18.4 bushels to market at 4c	.73
Plowing	3.75
Disking	1.50
Two harrowings at 50c	1.00
Seeding	1.00
One bushel of seed at $2.05	2.05
Taxes on land	.24
Interest on $60 land at 8%	4.80

End of First Crop Year

Harvesting	2.00
Threshing 18.4 bushels at 12c	2.21
Hauling 18.4 bushels to market	.73
Taxes on land	.24
Interest on $60 land at 8%	4.80
Total expense for 2 crops and 1 fallow	$44.10

Gross returns from 2 crops, 36.8 bushels at $2	$73.60
Net returns for 2 crops	29.50
Net returns per crop	14.75
Net returns per year	9.83

One Crop in Three Years.—The total yield of this test for sixteen years amounted to 105.5 bushels per acre, the average crop to 17.6 bushels, and an average per year of 6.6 bushels per acre. To determine the efficiency of this system in comparison to those already given the cost of the two fallows plus the cost of harvest and threshing, etc., was subtracted from the value of 17.6 bushels of wheat. This gave the net value per crop, and when divided by

3 the net returns for each year. The expense per acre for this cropping method follows:

Plowing (spring)	$ 3.25
Harrowing	.50
Weeding	1.00
Taxes on land	.24
Interest on $60 land at 8%	4.80
End of First Fallow Year	
One weeding	1.00
One harrowing	.50
Seeding	1.00
One bushel of seed at $2.05	2.05
Taxes on land	.24
Interest on $60 land at 8%	4.80
End of Second Fallow Year	
Harvesting	2.00
Threshing 17.6 bushels at 12c	2.11
Hauling 17.6 bushels to market at 4c	.70
Taxes on land	.24
Interest on $60 land at 8%	4.80
Total expense of 1 crop	$29.23
Gross returns from 17.6 bushels wheat at $2	$35.20
Net returns per crop	5.97
Net returns per year	1.99

The 16-year results of this cropping experiment given in Table XVII are sufficiently reliable to draw conclusions in respect to the profitableness of various methods of cropping. An examination of Table XVII shows that of the various methods the two crops in three years stood first with a net yearly return of $9.86, followed by one crop in two years with a return of $8.94. Although the difference between the two is 92c, yet the convenience and safety of the alternate method should be given some consideration. The land cropped the second year after a fallow was plowed immediately after harvest and made ready for seeding. This necessitates a rush with the work which often results in poor sed-bed preparation. With the alternate system the plowing in the test was done in the spring, but on farms this work could be divided between fall and spring to be done at convenient yet desirable times.

In comparison to the above two methods, the continuous cropping with a net return of $5.19 and one crop in three years with

$1.99 as a labor income are so plainly inferior that they need not be considered.

In 1915 twenty-four tenth-acre plats were added to the above experiment to cover a wider range of conditions as well as to have more replications and to secure results for every year in each test. The data for the five-year period of the experiment are given in Table XIX. In arriving at the net yearly returns the same costs were used as in getting the returns in Table XVII.

Comparing the averages given in Table XVII with similar tests in Table XIX the yields in Table XVII are seen to be considerably higher than in the former. The main reason for this difference is a larger proportion of unfavorable seasonal conditions since 1915 which have measurably reduced yields. The two crops in three years cropping method with fall plowing preceding the fallow of the first crop followed by double disking for the second gave the highest net value of $4.62. Returns for the other systems were $4.43 per year for two crops in three years with fall plowing for both; $4.25 per year from the alternate method; $2.84 for land cropped once in three years; $2.25 for continuous cropping; and 6c per acre for continuously cropped land disked after the crop was removed and before sowing the next. All of the above tests were operated at a profit, while the remaining ones brought losses. Land cropped continuously with no tillage showed a loss of $1.25; alternately cropped land with weeds and volunteer growth clipped just before disking immediately followed by seeding produced a yearly loss of $2.49; and alternately cropped land with weeds clipped but no tillage a yearly loss of $3.75 per acre.

From data given in Table XIX it is evident that the largest net returns per acre were produced by land cropped two years with one fallow, the first crop being produced after fall plowed fallow and the second after double disking. The data from both tables indicate that this method of cropping gives best net returns but is closely followed by the alternate cropping system. Under many conditions alternate cropping is safest and most convenient, yet the results given in the two preceding tables point to the two crops in three years as most efficient. The data in these tables further show that profitable returns are produced only through proper preparation of the seed-bed.

Rotations.—There are now twenty-seven rotations under test at the Nephi Substation. Most of them, however, have been started so recently that the results are not dependable, so only one which began in 1908 will be considered here.

Ever since fallowing became a part of the cropping system for wheat both scientific investigators and farmers have tried to find

Table XVIII. Yield of Wheat Produced on Single Fifth-acre Plats from Various Methods of Cropping with Total and Average Yield per Year, Average Yield per Crop, and Net Returns. Data cover a Period of 16 Years at the Nephi Substation.

Method of Cropping	Years Tested and Yield in Bushels per Acre																Total	Average per Year	Average per Crop	Net Returns per Year
	1904	1905	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919				
Continuous, (Fall Plowed)	17.7	8.1	17.9	16.5	13.4	14.6	7.8	5.7	6.0	4.5	24.0	12.8	8.3	16.5	11.4	2.0	187.2	11.7	11.7	$5.19
Alternate, (Spring Plowed)	15.2	F	35.6	F	25.0	F	9.9	F	4.8	F	41.0	F	15.3	F	20.4	F	116.3	10.4	20.8	8.94
2 Crops in 3 Years (Fall Plowed)	15.2	9.9	F	F	32.7	13.4	F	23.6	3.9	F	39.8	13.6	F	23.3	9.0	F	184.4	11.5	18.4	9.83
1 Crop in 3 Years (Spring Plowed)	16.2	F	F	32.9	F	F	5.0	F	F	11.2	F	F	18.6	F	F	21.6	105.5	6.6	17.6	1.99

Table XIX. Yield of Wheat, Peas, Potatoes, and Corn in a Continuous Rotation with Wheat after Fallow to Compare with Wheat after the Intertilled Crops. Results Secured from Single Tenth-acre Plats at the Nephi Substation.

Crop	Years Tested and Yield in Pounds and Bushels												Average per Crop
	1908	1909	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	
Corn after Wheat (lbs.)	1855	1240	40	40	1420	750	3310	2070	370	1360	750	0	1100 lbs.
Wheat after Corn	25.8	6.5	19.3	28.5	18.8	4.4	41.6	35.0	17.2	28.0	16.2	8.7	20.8
Peas after Wheat (lbs.)	1080	1050	35	0	315	115	180	840	660	740	570	0	465 lbs.
Wheat after Peas	30.1	2.2	18.3	29.5	17.8	4.2	41.3	41.8	17.5	24.2	16.0	8.7	21.0
Potatoes after Wheat	42.5	84.7	7.3	0	32.4	34.5	51.2	25.7	26.0	23.7	19.2	0	28.1
Wheat after Potatoes	22.6	2.5	17.2	32.1	18.7	4.2	43.0	34.8	18.7	25.0	17.1	5.5	20.1
Wheat after Fallow	27.5	4.6	13.7	30.0	14.7	2.0	39.3	44.8	23.5	28.2	16.3	12.8	21.5

some economic use for the uncropped land. In seasons of high rainfall during April, May, and June, potatoes, peas, corn, beans, and other crops have given fair returns, but in seasons of very low rainfall failure has been the rule.

At the Nephi Substation the results with a rotation of wheat, with corn, with potatoes, and with peas showed very little reduction in yield of wheat after any of these intertilled crops when compared with wheat grown after clean summer fallow. The value of the rotations rests with the profitableness of the crops used in place of the fallow; corn has given an average yield after wheat of 1100 pounds of fodder; peas 465 pounds total weight; and potatoes, 27.1 bushels. These average yields covering the period from 1908 to 1919 are very low, so low in fact that they are commercially unprofitable. As previously stated, however, the farmer has an opportunity to make profit from these crops if judgment is used in selecting a season with abundant moisture in the soil.

The experiment given in Table XVIII is planned so as to give results for every crop each season.

TILLAGE METHODS WITH WINTER WHEAT

The success or failure of crops on dry-lands depends primarily upon efficient tillage of the soil. In proper tillage, however, does not lie the solution of all cultural dry-farm problems; the time of tilling is of considerable importance. In the following discussion the time and dpeth of plowing, care of the fallow, and cultivation of the growing crop will be considered.

All the tests from which the following data have been taken were cropped according to the alternate system, but the experiments are so arranged that results appeared every year. The plowing, unless otherwise stated, was about 8 inches deep in all tests.

Time of Plowing.—The cultural operation deserving most careful consideration on the dry-farm is plowing. During the last sixteen years various plowing experiments have been conducted at the Nephi Substation, but most of the tests before 1910 are not consistent enough to publish. The plowing experiments included spring compared with fall plowing followed by various treatments of the fallow, deep compared with shallow plowing, deep fall plowing followed by shallow spring plowing, and shallow fall plowing followed by deep spring plowing.

Fall vs. Spring Plowing—Ordinary Cultivation of Fallow.—The preparation of land for this test began in 1908, and the first results appeared in 1910. Previous to 1908 the plats were cropped to wheat each alternate year. The preparation for the test

Table XIX. Yield of Turkey Wheat Produced at the Nephi Substation by Various Methods of Cropping with Total Average Yield per Year with Net Returns in Cash Value from 1915 to 1919, Inclusive.

Method of Cropping	Years Tested, Yields in Bushels						Average per Year.	Average per Crop.	Net Return per Year.
	1915	1916	1917	1918	1919	Tot'l			
Alternate, spring plowed	7.7	F	23.3	F	12.0	42.0	8.4	14.0	
Alternate, spring plowed	F	15.3	F	20.4	F	35.7	7.1	17.8	
Alternate, spring plowed	8.3	F	26.5	F	18.0	52.8	10.3	17.6	
Alternate, spring plowed	F	9.9	F	16.9	F	26.8	5.4	13.4	
Average	8.0	12.6	24.9	18.6	15.0	39.3	7.8	15.7	$4.25
Alternate, fall disked	13.0	F	8.7	F	2.1	23.8	4.8	7.9	
Alternate, fall disked	F	4.3	F	6.2	F	10.5	2.6	5.3	
Average						17.1	3.7	6.6	2.49
Alternate, no tillage	9.8	F	7.8	F	1.7	19.3	3.9	6.4	
Alternate, no tillage	F	1.3	F	3.0	F	4.3	.9	2.1	
Average						11.8	2.4	4.2	3.75
Continuous, fall plowed	12.8	8.3	16.5	11.4	2.0	51.0	10.2	10.2	
Continuous, fall plowed	8.4	10.4	18.7	9.2	2.7	49.4	9.9	9.9	
Average	10.6	9.3	7.6	10.3	2.3	50.2	10.1	10.1	2.25
Continuous, fall disked	10.5	3.6	10.8	5.2	2.3	32.4	6.5	6.5	
Continuous, fall disked	10.8	3.6	11.2	5.8	2.0	33.4	6.7	6.7	
Average	10.6	3.6	11.0	5.5	2.1	32.9	6.6	6.6	.06
Continuous, no tillage	8.9	3.2	7.8	2.3	2.7	24.9	5.0	5.0	
Continuous, no tillage	7.3	3.6	6.0	3.8	2.3	23.0	4.6	4.6	
Average	8.1	3.4	6.9	3.0	2.5	23.9	4.8	4.8	1.25
Two crops in 3 years	*13.6	F	23.3	9.0	F	45.9	9.2	15.30	
Fall plowed	F	17.3	19.5	F	16.3	53.1	10.6	17.70	
Fall plowed	8.5	8.4	F	15.7	3.3	35.9	7.1	9.0	
Average						45.0	9.0	14.0	4.43
1st crop after fallow	8.5	17.3	23.3	15.7	16.3	81.1	16.2		
2d crop after fallow	13.6	8.4	19.5	9.0	3.3	53.8	10.8		
1 crop in 3 years	F	18.6	F	F	21.6	40.2	8.0	20.1	
Spring plowed	10.8	F	F	19.7	F	30.5	6.5	15.2	
Spring plowed	F	F	26.5	F	F	26.5	5.3	26.5	
Spring plowed	F	17.0	F	F	15.8	32.8	7.8	16.4	
Spring plowed	9.4	F	F	15.2	F	24.6	4.9	12.3	
Spring plowed	F	F	23.5	F	F	23.5	4.7	23.5	
Average	10.2	17.8	25.0	17.4	18.7	29.7	6.2	19.0	2.84
Rotation of wheat after fall	10.5	11.4	F	16.0	1.3	39.2	7.8	9.8	
plowed fallow followed	F	18.2	16.7	7.2	F	42.2	8.4	14.1	
by wheat after disking	15.2	F	22.2	F	7.5	44.9	9.0	15.0	
Average						42.1	8.4	13.0	4.62
Wheat after fall plowed fallow	10.5	18.3	22.2	16.0	7.5	74.5	14.9		
Wheat after wheat disked in	15.2	11.4	16.7	7.2	1.3	51.8	10.4		

F—Fallow.
*—Second crop.

began with fall plowing for one plat and spring plowing for the other. Both were harrowed in spring. The fall-plowed plat has usually produced a vigorous growth of volunteer grain and weeds which required an extra cultivation, while with the plat spring

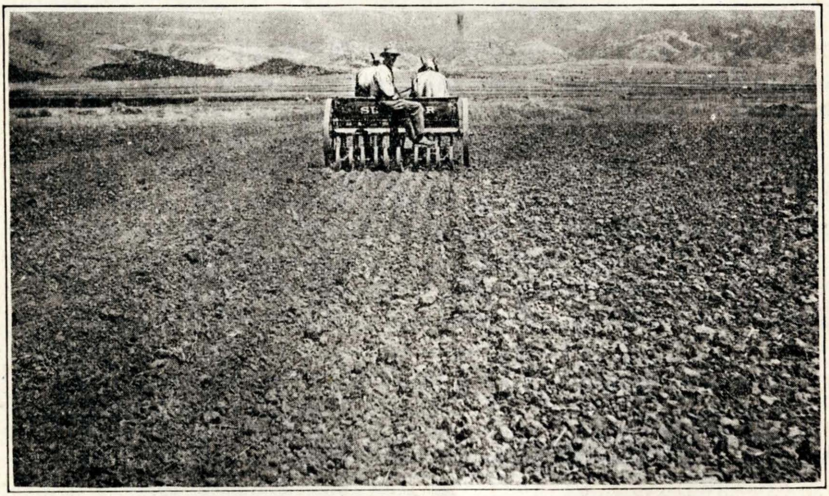


Fig. 2.—A good seed-bed on a dry-farm. A mulch of small clods is better than a fine dust mulch.

plowed the weed growth was destroyed by the spring plowing. Therefore, during the fallow periods the spring-plowed plat required only one weeding, but the fall-plowed plat required two. Before sowing wheat in the fall another harrowing was given both plats. Uniformity was maintained as nearly as possible for all cultural and seeding operations. Table XX gives the yield of wheat produced by plats in this experiment from 1910 to 1919, inclusive.

The average results show that practically no difference existed in yield between spring and fall plowing. At present rates fall plowing costs about 50c more per acre than spring plowing to which must be added $1 for the extra weeding, making the difference between the two approximately $1.50 per acre for the cultural operations. The spring plowing in this experiment was done at a time when the land was in the best condition, this period at Nephi being not longer than two or three weeks. If all plowing on large farms were left until spring much would of necessity be plowed too late to give good results. For this reason it is advisable to plow enough of the land in fall so that the part left can be plowed at the proper time in the spring.

Fall vs. Spring Plowing—Fallow Hoed to Kill Weeds.—This

Table XX. Annual and Average Yields of Turkey Wheat in Bushels per Acre Obtained on Fall-plowed and Spring-plowed Land Alternately Cropped and Fallowed at the Nephi Substation During the Ten Years from 1910 to 1919, Inclusive.

Treatment	Yield in Bushels per Acre										Average
	1910	1911	1912	1913	1914	1915	1916	1917	1918	1919	
Plowed in Spring Previous to Seeding	14.0	33.0	22.0	5.0	42.8	31.7	18.3	31.8	14.5	23.7	23.7
Fall Previous to Seeding	12.0	29.0	22.0	4.0	45.5	31.3	19.3	27.8	16.2	19.3	23.6

test was made to determine whether the increase in yield following cultivataion of fallow was due to the eradication of weeds or to a reduction in evaporation caused by stirring the surface soil. The results date from 1916. Before 1916 the plats had been alternately cropped and fallowed since 1904. As four plats were used in the test, results appear every year. All weed growth was hoed with the least possible stirring of the surface. The treatment given the plats after plowing was as uniform as possible except that the fall plowed plat needed more weedings. The annual and average yields of winter wheat appear in Table XXI.

Table XXI. Annual and Average Yields of Turkey Wheat Grown at the Nephi Substation on Single Tenth-acre Plats Spring and Fall Plowed with Weeds Hoed. Data from 1916 to 1919, Inclusive.

Treatment	Yield in Bushels per Acre				Average
	1916	1917	1918	1919	
Fall plowed, Weeds Hoed............	17.8	31.2	13.2	21.7	21.0
Spring plowed, Weeds Hoed..........	19.5	29.2	13.0	23.0	21.2

Fall vs. Spring Plowing after Fall Disking.—Disking wheat land immediately after harvest followed by fall and spring plowing was added to the tests of tillage methods at the Nephi Substation in 1916. The plats used for the test had previously been alternately cropped since 1904. The preparation for sowing began by double disking two plats immediately after harvest. Later one was fall plowed and the other was not plowed until spring. Both were treated in the same manner during the fallow period except that the fall-plowed plat was given one more weeding than the spring-plowed plat. The latter plat received one spring harrowing, one summer weeding, and one fall plowing before sowing to wheat. The results for this test are given in Table XXII.

Table XXII. Average and Annual Yield of Turkey Wheat at the Nephi Substation from Single Tenth-acre Plats Disked Immediately after Harvest, later one Fall and one Spring Plowed.

Treatment	Yield in Bushels per Acre				Average
	1916	1917	1918	1919	
Spring plowing after Fall disking	16.0	24.7	11.2	17.3	17.3
Fall plowing after Disking	18.8	25.7	15.8	16.7	19.2

There was a difference in yield of 1.9 bushels per acre in favor of the plats disked and later fall plowed. But when the yields of this test are compared to those from ordinary fall or spring plowing fallowed by usual summer tillage, the difference is decidedly in favor of the ordinary method. Disking has not given a profit; in fact, the comparison with the ordinary method indicates a loss.

Frequent Cultivation of Fallow—Spring and Fall Plowed Land.—This test was started to determine the advantage of frequent over ordinary cultivation of fallow land. The land had been alternately cropped to winter wheat from 1904 to 1914, inclusive. Preparation for this test began by fall plowing two plats in 1914. One of these plats was plowed again the following spring. The other was harrowed as early as possible and then received two weedings as needed. The third plat was spring plowed and harrowed immediately after plowing. The latter plat, together with the one fall and spring plowed, received one summer weeding.

All plats were harrowed on June 1 and every two weeks thereafter during the fallow period until September 1. This made a total of eight harrowings during the season.

Table XXIII. Annual and Average Yields of Wheat in Bushels per Acre at the Nephi Substation for a Period of Four Years on Single Tenth-acre Plats Harrowed Every Two Weeks During the Fallow Period One Fall, One Fall and Spring, and One Spring Plowed.

Treatment	Yield in Bushels per Acre				Average
	1916	1917	1918	1919	
Fall plowed	17.3	27.0	13.6	21.0	19.7
Fall and spring plowed	17.6	28.5	16.7	22.5	21.3
Spring plowed	18.3	26.4	13.5	19.3	19.4

The average results given in Table XXIII show a difference of 1.6 bushels in favor of plowing both in the fall and spring as compared to fall plowing only, and small difference in favor of fall over spring plowing. Comparing these yields with those given in Table XX, a difference of 2 to 4 bushels occurred in favor of the ordinary tillage methods. From these results it is evident that the six extra harrowings, allowing two for the ordinary method, were given at a loss.

Fall and Spring Plowing to Various Depths.—Where the land fall plowed is kept continuously wet from early until late spring before the fallow can be cultivated even the best of weeders will not kill the volunteer growth. Under such conditions plowing is the only alternative. During the last four years beginning with 1916 six tenth-acre plats have been alternately cropped and fallowed to determine the effect of 8- and 3-inch plowing in fall followed by 3-and 8-inch plowing, respectively, in spring on the yield of Turkey wheat; also one plat plowed 8 inches in fall and again to the same depth in spring. The arrangement of the test with three plats in fallow and three in crop allow results every year. The yields of this test are given in Table XXIV.

Table XXIV. Annual and Average Yields of Wheat Produced at the Nephi Substation on Single Tenth-acre Plats Alternately in Crop and Fallow from Various Depths of Fall and Spring Plowing.

Treatment	Yield in Bushels per Acre				Average
	1916	1917	1918	1919	
Plowed 8 inches in fall, 3 inches in spring	16.5	26.2	18.2	17.3	19.5
Plowed 3 inches in fall, 8 inches in spring	14.5	28.2	14.3	15.5	18.1
Plowed 8 inches in fall, 8 inches in spring	15.7	26.8	15.8	17.0	18.8

The variation in average yield between the tests being within one and a half bushel per acre show no one method to be decidedly advantageous; the short length of the trial reduces the difference to negligible quantities. The yields of these plats were at least four bushels under either a single or spring plowing shown in Table XX.

Depth of Fall Plowing.—Efficient plowing is one of the requisites to successful dry-farming. This does not necessarily mean deep plowing, nor does it mean shallow plowing, but a thorough tillage of the soil to a depth of five to ten inches.

A depth of plowing test on alternately cropped land began at the Nephi Substation ini 1904, but the results before 1910 are not reliable enough to be given. For each test there were two plats; so that results were obtained for each year. All plowings were given in fall after harvest. In years before 1915 the spring volunteer and weed growth were either double disked out or plowed under; now a weeder is used for this purpose. Usually two weedings after an early spring harrowing have been necessary, followed by another harrowing just before sowing time. In subsoiling the subsoiler is followed by the plow. The yields of grain for this experiment are given in Table XXV.

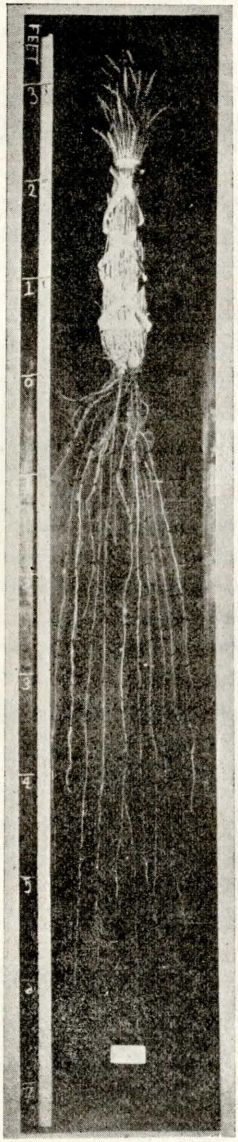


Fig. 3.—**Wheat plant** taken from the Nephi Substation, showing the depth to which roots go for moisture.

The average yields of grain indicate only small differences for the various depths of plowing. The widest range existed between the 10- and 15-inch plowing both with an average 9-year yield of 21.7 bushels and the 18-inch sub-soiling with a yield of 20.2 bushels. Between plowing to a depth of 5 inches and the next two depths the difference was only .8 bushels. Approximate costs of plowing at the various depths will help indicate the best practice. At Nephi in 1919 a 5-inch plowing could be contracted for $3.25 per acre and plowing to a depth of 10 inches for about $4. For the 15- and 18-inch subsoiling two outfits are necessary; one man with three horses and a plow; another man with four horses and the subsoiler. About an acre a day could be subsoiled with the two outfits. At once it is seen that subsoiling does not pay on Levan Ridge soils. The proper depth to plow, according to these results, is between 5 and 10 inches, but the exact depth cannot be stated since it is difficult to strike the point at which the most profitable returns are secured.

Table XXV. Annual and Average Yields of Turkey Wheat When Grown at the Nephi Substation on Single Tenth-acre Plats Plowed to Various Depths.

Treatment	Yield of Grain in Bushels per Acre									Average
	1910	1911	1912	1913	1914	1916	1917	1918	1919	
Subsoiled 18 inches deep......	14.0	28.0	18.0	4.0	38.6	16.2	27.7	16.5	19.0	20.2
Subsoiled 15 inches deep......	13.0	29.0	19.0	6.0	41.3	15.8	27.2	20.3	23.7	21.7
Plowed 10 inches deep......	13.0	29.0	21.0	7.0	38.8	15.7	28.2	17.3	25.5	21.7
Plowed 5 inches deep......	12.0	27.0	20.0	10.0	39.5	13.3	28.5	13.7	23.8	20.9

Spring Cultivation of Winter Wheat.—In some seasons a combination of unfavorable winter and spring conditions cause the formation of a crust an inch or so thick at the surface of the ground. There is no question that such a soil condition is detrimental to growing wheat. As the crust gets deeper the soil cracks, allowing moisture to escape, and the hard surface does not permit a free tillering of the plants. Spring harrowing, theoretically, should correct this unfavorable soil condition, but experience has proved that it is impossible to break a hard crust without seriously reducing the stand. In this test the cultivation was not so severe.

The experimental results from 1909 to 1915, inclusive, are given in Table XXVI.

Table XXVI. Annual and Average Yields of Turkey Wheat Grown at the Nephi Substation on Single Tenth-acre Plats Cultivated in Spring and Uncultivated.

Treatment	Yield per Acre of Grain in Bushels							Average
	1909	1910	1911	1912	1913	1914	1915	
Cultivated	8.3	19.0	27.9	14.9	9.8	33.6	25.3	19.8
Uncultivated	12.7	19.5	27.7	14.9	10.5	28.5	25.0	19.8

The average yields in this test are identical indicating that the extra cultivation was of no practical use. The cultivated plat received one harrowing when the plants were about three to four inches high.

Rate of Sowing Winter Wheat.—A rate-of-seeding test with winter wheat began on the Nephi Substation in 1904, but before 1910 results were obtained only during part of the year. From

1910 to 1919, inclusive, yields were secured every year except for 1912 and 1918. In 1912 the test was not seeded; in 1918 either the formalin treatment or some physical injury to the seed was the cause of complete failure. From 1910 to 1916, single tenth-acre plats were used and from 1917 to 1919 duplicate twentieth-acre plats. Turkey (C. I. No. 2998) was used from 1910 to 1919, inclusive, as one of the fall varieties, and from 1915 to 1919, inclusive, Kofod (C. I. No. 2997) was added. From 1910 to 1916 the rates of seeding were 2 to 6 pecks, and 1917 to 1919, 2 to 8 pecks.

Table XXVII. Annual and Average Yields of Winter Wheat in Bushels per Acre With Different Rates of Seeding.

Rate of Seeding	C. I. No.	Years Tested and Yield in Bushels per Acre								Average
		1910	1911	1913	1914	1915	1916	1917	1919	
Turkey										
2 pks.	2998	16.0	23.5	0	25.7	28.0	22.5	17.4	16.3	18.7
3 pks.	2998	19.3	21.3	2.7	32.8	30.8	20.2	19.6	18.1	20.6
4 pks.	2998	19.3	28.7	3.0	38.7	34.5	20.8	21.6	19.4	23.2
5 pks.	2998	19.3	33.7	2.9	44.2	37.3	22.1	22.3	21.5	25.4
6 pks.	2998	17.0	30.3	3.0	46.5	36.7	25.8	24.8	21.0	25.6
7 pks.	2998							26.3	23.5	24.9
8 pks.	2998							28.3	22.5	25.4
Kofod										
2 pks.	2997					22.0	13.7	17.1	12.5	16.3
3 pks.	2997					21.4	17.1	20.0	15.3	18.5
4 pks.	2997					22.8	17.1	20.1	17.0	19.2
5 pks.	2997					25.7	17.7	20.2	17.7	20.3
6 pks.	2997					26.9	22.4	21.8	17.1	22.0
7 pks.	2997							23.6	18.3	20.9
8 pks.	2997							24.0	15.3	19.6

At one time farmers in the Great Basin area usually seeded near 3 pecks of fall wheat to the acre more than this now used as a rule. An examination of Table XXVII shows that heavy seeding is profitable. The higher the rate of sowinng until 5 or 6 pecks per acre are reached the larger the yield, although above these quantities the yield tended to remain the same. Even in years of extreme drouth, such as occurred in 1919, the higher rates proved most efficient. It is likely that 3 pecks per acre would be sufficient if all seeds survived, but it has been found at Nephi that the average winter survival among fall-sown cereals is about 65 per cent. This leaves only about 30 pounds of the 45 to produce plants that mature. On lighter soils and in sections of heavier fall precipitation it is likely that lower rates of seeding would be best.

OTHER FARMS

SAN JUAN COUNTY FARM

The San Juan County Farm was operated from 1905 to 1916. During the first years rather extensive cultural and varietal tests were carried on, but later it was found advisable to centralize these experiments at Nephi using the other farms largely as sources of pure seed for the districts in which they were located. Records of yields were not kept during several of the years.

The San Juan County farm was among the most successful of the farms. The average yield of Lofthouse wheat on 13 plats during the years 1905, 1906, and 1907, was 20.2, 26.2, and 31.5 bushels, respectively, or an average of 26.0 bushels per acre. Turkey wheat gave an average yield of 22.0 bushels in 1910 and 31.9 bushels on 34 acres in 1915.

The spring varieties of wheat was not so successful, as shown by the following figures obtained from averages of the years 1905, 1906, and 1907: Kahla, 9.5; Black Don, 15.3; Medeah, 11.8; Mohamed Ben Bachir, 11.3; Mohmoud, 12.3; Salzer's Fife, 11.8; Wellman's Fife, 22.3; Romanon, 25.7; and Whitington, 8.9 bushels per acre.

The average yield of oats obtained during 1905, 1906, and 1907 was as follows: Sixty-day, 21.6; Kherson, 17.6; Northwestern White, 27.3; and Prince Edward's Island, 24.8 bushels per acre.

During the same year the spring barley varieties yielded 18.0 bushels per acre for California, 18.9 bushels per acre for California Polific, and 18.5 bushels per acre for Mansbury.

The yield of grasses was not entirely satisfactory. An average of three tests for *Bromus inermis* gave 1,898 pounds to the acre, while tall meadow oat grass yielded but 752 pounds. During highest yield of alfalfa was 1,542 pounds to the acre. During most of the years records were not kept of yields as the crop was used as pasturage for animals on the farm.

It will be seen from these figures that fall wheat was much more successful on this farm than any other crop. The cultural tests were too brief to give any definite results, but in general they indicated the same results that have been reported for Nephi.

WASHINGTON COUNTY FARM

The farm at Enterprise, like the San Juan County Farm, was used only during the first few years for experimental purposes being devoted to pure seed growing from 1908 to 1915, when it was abandoned. This was one of the moderately successful of the first experimental dry-farms. The yields of Turkey and

Lofthouse wheat during years when records were kept are given below:

Year	Yield in Bushels per Acre	
	Turkey	Lofthouse
1904	11.5	12.2
1905	22.9	11.9
1906	11.1	16.4
1907	27.3	27.6
1908	23.7	18.7
1910	11.0	
1914	18.0	
Average	16.5	17.4

Varietal tests from 1904 to 1908 with wheats other than the above two show that Winter La Salle, Red Chaff, and New Zealand with yields of 18.2, 19.9, and 14.1 bushels per acre, respectively, were the only ones with averages above 10 bushels for the 5-year period.

Barley, rye, and oats each averaged slightly over 6 bushels to the acre. The average production of corn during the 5-year period was about 16 bushels of ear grain and three-fourths of a ton of stover to the acre. Forage crops, including alfalfa. brome grass, and tall meadow oat grass have been tried, but the yields were scarcely more than one-fourth of a ton to the acre.

TOOELE COUNTY FARM

The experimental results of the Tooele County Farm extend from 1904 to 1908. During this period the average yields of winter wheats were as follows: Turkey, 17.2; Lofthouse, 17.4; Kofod, 18.8; Gold Coin, 18.3; Red Chaff, 16.6; Odessa, 14.7; Richi, 14.0; Sonora, 13.9; and Bluestem, 13.9 bushels. None of the spring wheats averaged as high as 10 bushels to the acre.

Barley, corn, and oats all failed to give average yields as high as 15 bushels to the acre.

KANE COUNTY FARM

The farm at Kanab, Kane County, was established in 1914 and produced the first results in 1915. During the spring of 1915 barley, Sudan grass, corn, beans, and potatoes were sown. The yields per acre for the years 1915, 1916, and 1917 were as follows:

Crop	Yields in Bushels and Pounds per Acre		
	1915	1916	1917
Turkey wheat (bu.)	12.4	19.4	9.0
Spring barley (bu.)	11.8	13.6	
Corn (bu.)	10.7		
Sudan grass seed (lbs.)	271		
Beans (lbs.)	253		
Potatoes (lbs.)	354		

Tests of several varieties of beans during 1917 gave the following results:

Tepary beans	5.75 bu. per acre
Navy beans	2.47 bu. per acre
White kidney beans	2.48 bu. per acre
Pink beans	1.11 bu. per acre

In 1918 no Turkey wheat was raised. Marquis wheat produced 4.8 bushels per acre. Corn failed to mature on account of an early frost.

The results for 1919 were not satisfactory because of serious attacks on the crops by rabbits. The yields were as follows:

Turkey wheat	5.0 bu. per acre
Kubanka wheat	1.7 bu. per acre
Marquis wheat	3.8 bu. per acre

An almost continuous drouth during 1917, 1918, and 1919 has made results on the farm unsatisfactory, but it is believed that during normal years wheat, corn, and beans can be successfully raised.

GARFIELD COUNTY FARM

The farm at Widtsoe, Garfield County, was selected in June 1917, but it was not until 1918 that it was plowed. On August 31, 1918, three and one-half acres of Turkey wheat were seeded. In the spring of 1919 several varieties of wheat, barley, oats, and field peas were sown, but the drouth was so severe that all of the crops failed to mature. The outlook of this farm is promising in spite of this failure.

CEDAR CITY FARM

When the farm at Enterprise was abandoned the equipment was moved to Cedar City where the operation of a dry-farm was begun in cooperation with the Branch Agricultural College. Since the farm was established there has been a continuous succession of dry years so that no satisfactory crops have been secured, although all of the common dry-farm crops have been seeded.

OTHER FARMS

As stated in the historical review of the dry-farms, a number of the farms were abandoned without securing any positive experimental results. When crops are practically failures it is impossible to interpret differences between varieties and cultural treatments. The farms in Rush Valley, Cedar Valley, Iron County, and Sevier County all failed to produce successful crops. Failures were due largely to unfavorable natural conditions, but in cases such as the Rush Valley Farm the lack of adequate supervision was an important item in the failures.

SUMMARY

This bulletin summarizes the important findings from dry-farm experimental stations located in Juab, San Juan, Washington, Tooele, Iron, Sevier, Kane, Utah, and Garfield Counties, Utah.

The experiments have shown that many parts of Utah are adapted to dry-farming, but there are also many places where it cannot be made to succeed with our present knowledge of the dry-farm practice.

Climatic conditions largely determine the success of dry-farming in Utah.

Winter wheat is by far the most important dry-farm crop. Crimean, Turkey, Beloglina and Bulgarian varieties of winter wheat have given the best average yields over a long period of time.

Spring wheats are sometimes useful where winter wheat has failed to give a satisfactory stand. The best yielding varieties of common spring wheats have been Chul, Saumur, Early Baart, Ghirka Spring, and Koola. The best yielding durum spring varieties have been Kubanka, Adjini, Mohamed Ben Bachir, and Velvet Don.

Barley ranks next to wheat in yield of grain on the experimental dry-farms. Bulgarian and Turkestan winter varieties have shown great promise. Spring barleys have not yielded satisfactorily.

Oats have not been grown successfully on Utah experimental dry-farms.

Corn, peas, beans, and potatoes have not given good results on the dry-farms except in seasons of high spring rainfall. These crops when grown during the otherwise fallow season give fair yields without greatly affecting the following wheat crop. The rainfall before seeding time largely determines whether these crops will succeed during a given season. Sowing every year in rotation with wheat has not given a profit.

Alfalfa with an average yield of nearly a ton to the acre at Nephi ranks highest as a dry-farm forage crop. Sweet clover, tall meadow oat-grass, and brome-grass give fair yields but are

open to serious objections. Rye makes a good forage for pasture crop, especially on land unsatisfactory for other purposes.

Cropping two years in three has given the largest net returns per year with wheat, although alternate cropping has certain advantages which make it the more desirable practice under many conditions.

At Nephi spring plowing immediately followed by harrowing, with one weeding and another harrowing just before fall seeding has proved to be the most economical method of preparing the seed-bed for fall sowing under the alternate system of cropping.

Disking dry-farm land in the fall immediately after harvesting was not profitable.

The best depth to plow appears to be between 5 and 10 inches.

Spring cultivation of winter wheat was done at a loss.

Winter wheat yielded best when sown at the rate of about six pecks to the acre.

(College Series 147)