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Circular No. 21 - Dry-Farming in Utah

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A. D. Ellison

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Dry-Farming In Utah

BY

F. S. HARRIS and A. D. ELLISON

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UTAH AGRICULTURAL EXPERIMENT STATION

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I. Development of Dry-farming in Utah.

It was only a few years after the settlement of Utah in 1847 that occasional attempts were made to raise crops without the use of irrigation water, but these first attempts usually resulted in failure. Not until in the sixties could any degree of success be claimed. About this time, farmers in the valley of the Great Salt Lake and in Cache Valley began raising crops regularly on land located above the canal. From then to the present time a measure of success has been enjoyed by the better dry-farmers in some sections, and hardly a year of complete failure is to be found in their records.

During these early years, dry-farming was practiced by but few settlers, and only in a limited number of localities. Great tracts of land were still available under the canals, and it was not necessary to resort to this little-understood method of farming. In the nineties, however, as irrigated land became scarcer, more and more attention was given to the sagebrush lands that could not be covered with water. Farmers who had previously been skeptical began to inquire if it were really possible by the use of certain tillage methods to produce crops with only the natural precipitation. The small areas where dry-farming had already been practiced gradually expanded and new regions were investigated. The man who believed dry-farming possible was no longer looked on with the degree of suspicion that attended the first dry-farmers.

In 1901 Dr. John A. Widtsoe, Director, and Professor L. A. Merrill, Agronomist, of the Utah Experiment Station began an investigation and found that dry-farming was being successfully practiced in a great many parts of the State. In 1903 the State Legislature appropriated money for the establishment of six experimental dry-farms. This may be considered the foundation of dry-farming in the State as a permanent system of agriculture based on known laws of science. Before this time the methods were not well founded, since definite knowledge was very meager. The experiments which were begun at this time have
furnished exact data on which a rational system of arid agriculture must be based.

The passage of the Smoot-Mondell Bill by the United States Congress providing for homesteads of 320 acres of dry-farm land in certain of the Western States, did considerable to bring dry-farming to the front. The great publicity given the industry about this time caused many who were entirely unfamiliar with arid conditions to take up homesteads. The care taken in the selection of land by earlier workers in dry-farming was neglected by these newcomers, who were going to get rich by short-cut methods. The long list of failures which followed these slipshod methods of selecting farms and managing them testifies to the need of exact information, intelligently applied, if the arid lands of the West are ever to be permanently brought under the plow. A person inexperienced in farming and unfamiliar with arid conditions is probably no more likely to succeed at dry-farming on new land than a man without business experience would be if he entered Wall Street to compete with brokers who had been in the business all their lives.

Dry-farming, at best, means farming under difficulties. If it is to be successful every precaution must be taken to get a farm so situated that it can be made to pay; then the best tillage methods must be followed. The idea entertained by some people that they can get a farm from the Government for nothing and then sell it for a high price as soon as they get titles is responsible for many of the failures in dry-farming. This class of people does not expect to become farmers, but takes up the land as a speculation. In the past these speculators have lost most of the money they have invested, while those who have been wise in the choice of land and have devoted themselves honestly to its development as good farmers should, have usually succeeded.

That dry-farming, when properly practiced, has been successful cannot be denied by anyone who has made a thorough investigation of the subject. True, failures have been numerous but these can almost always be traced to poor judgment in selecting land, to careless methods of farming, or to poor business administration. Considerable experience seems to justify the
statement that, under proper conditions, dry-farming is just as successful and profitable as any other branch of agriculture.

II. Theory of Dry-Farming.

If plants did not require such large quantities of water for their growth, agriculture could be carried on in dry regions as successfully as in regions having a heavy rainfall. Lack of water is the principal reason for the lack of abundant vegetation where rainfall is light. Plants require several hundred pounds of water in order to make a growth of one pound. This means that each day a growing plant such as wheat and corn requires several times its own weight of water.

Water enters the root hairs and passes up the stem to the leaves where it is evaporated, or transpired through little openings called stomata. If for any reason water cannot be supplied from the soil through the roots, the water that is already in the plant evaporates until the plant becomes so dry it dies. For this reason if the soil does not contain sufficient moisture to furnish the needs of plants the production of crops is impossible.

In arid regions soils are usually abundantly supplied with all the plant-food elements. There is a great deal of sunshine, and all other conditions are favorable to plant growth with the exception of moisture which, on this account, becomes the chief limiting factor in arid agriculture. Where water can be had in running streams or in reservoirs this deficiency can be supplied by irrigation, but where water cannot be obtained in this way crop production depends on the economical use of the natural precipitation.

Dry-farming is, therefore, a system of agriculture where every known means is employed to increase the efficiency of a scant rainfall. A soil is selected which is capable of storing considerable moisture; it is handled in such a way that as much as possible of the precipitation will soak into the ground, and at the same time as little as possible be lost by evaporation. Crops that can withstand drouth are used and every device employed to assist them to use water economically. Even when all these precautions are observed, dry-farming with our present knowledge cannot be made successful in parts of the State where the rainfall is lowest.
III. Selecting a Dry-farm.

Too much stress cannot be placed on the importance of using proper judgment in the selection of a dry-farm. Great sums of money are wasted every year due to the fact that farms are selected in haste and improvements made before it is discovered that the area chosen cannot be made to produce crops by dry-farming methods. The earnings of a lifetime may easily be squandered by trying to farm under unfavorable conditions.

In selecting a dry-farm a number of factors should be examined very carefully. Among the most important are rainfall, soil, natural vegetation, and nearness to market.

Rainfall.

It is useless to attempt dry-farming unless the rainfall, when conserved, is sufficient to meet the needs of crops. Promoters

![Distribution of rainfall by months over typical sections of Utah.](image)
and it is much more certain with a precipitation above fourteen inches.

A number of factors affect the efficiency of a given quantity of rainfall. For example, it is less efficient where evaporation is high, where the soil will not absorb and store the water that falls, and where the distribution of rainfall throughout the year is not favorable.

The distribution of rainfall in a number of typical areas of
Fig. 3.—Comparison of precipitation and evaporation at the Nephi dry-farm sub-station, from April to October.

Fig. 4.—Average wind velocity at the Nephi dry-farm sub-station from April to October.
the State is shown graphically in Figure 1, which brings out the
great seasonal differences in precipitation. At Salt Lake City,
for example, more rain falls during March, April, and May than
in any other months, while in St. George, April, May, and June
are the months of lowest precipitation. In Richfield and Castle­
dale, a low precipitation is fairly well distributed throughout
the year, while in Kanab and Monticello where the precipitation
is comparatively high, certain months have very much more rain­
fall than others. Moisture falling late in the summer after
most of the crops matured is perhaps of less value than that fall­
ing at any other time during the year.

Figure 3 shows the comparison between the rainfall and the
evaporation at the Nephi sub-station, and Figure 4 shows the
average wind velocity during the growing season at the same
place.

Soil.

A soil that cannot hold a comparatively large quantity of
water is of no value for dry-farming. In regions like the Great
Basin where little of the water falls during the growing season,
it is especially important for the soil to be able to hold sufficient
water to mature a crop. A high water-holding capacity implies

Fig. 5.—Deep, uniform soil well adapted to dry-farming.
considerable depth of soil, since if it is only two or three feet deep it cannot hold, even if saturated, sufficient water to meet the demands of crops during a rainless summer.

Gravel streaks detract greatly from a soil's value for dry-farming, since they prohibit the rise by capillarity of water that has once passed farther down. The soil should not be too coarse else its water-holding capacity is reduced below a desirable limit. Nor should the soil grains be too fine, since a heavy clay causes difficulty in the numerous tillage operations that are necessary.

In selecting a dry-farm soil, careful examinations should be made at many points. Any washes or cuts that show the nature of the soil well should be studied, and borings made with an auger or tube at numerous places over the field. In regions where injurious quantities of alkali are likely to be present, samples of the soil should be submitted to a chemist for analysis. The presence of alkali can to a considerable extent be judged by the kind of plants that grow on the land.

Native Vegetation.

The native vegetation gives one of the best means of judging the adaptability of land to dry-farming. If the vegetation is scant, the indications are that the rainfall is low, or the soil is not adapted to the growth of crops. Occasionally soils are found which produce fair yields where the natural plant growth is small, but this is the exception.

The species of plants are valuable indicators of the quality of soil. Over most parts of Utah, sagebrush (Artemisia tridentata)
and certain grasses are considered to indicate a good soil, while greasewood (Sarcobatus vermiculatus) and shadscale (Atriplex confertifolia) indicate soils less well adapted to dry-farming.

If, then, a soil is of uniform texture to a depth of eight or ten feet and supports a vigorous growth of sagebrush, it may be considered to be favorable for dry-farming. On the other hand, if it is not uniform and contains streaks of coarse sand and gravel, or if it supports only a sparse growth of greasewood or shadscale, it should be given a very careful investigation before being selected as a dry-farm.

Markets and other factors.

A farm may be located on the best of soils and receive ample rainfall, but if the cost of marketing its products is greater than the returns, the farm cannot be made to pay. Dry-farms are likely to be located at some distance from settled regions; hence, the question of marketing must be taken into consideration. Grain cannot be hauled great distances by team and compete in price with that which does not have to be thus transported. It is often possible, however, to overcome in part this difficulty by raising sufficient stock on the isolated farm to consume the crops.

The question of water for culinary purposes and for the farm animals should be taken into consideration in selecting a dry-farm. Profits are greatly reduced if all the water that is used has to be hauled fifteen or twenty miles.

The possibility of being able to make a desirable, permanent home should also be considered, for in addition to being a place to make money, the farm is also a place to live. If it is so situated that it can never be made a desirable place of residence, its attractiveness is greatly reduced for the settler who is desirous of having a new home. As a rule it is more difficult to make a home on a dry-farm than on an irrigated farm.

IV. Preparing Virgin Land for Cropping.

It is probable that more failures in dry-farming in Utah have resulted from lack of thoroughness in preparing for seeding than from any other cause. Many farmers have expected returns too soon and as a result have lost everything. Their financial condition has been such that they could not afford to wait two or
three years, and consequently their haste has often forced them entirely out of the business.

Most new farmers who are unfamiliar with arid conditions, after breaking up their land in the late summer, want to plant it to fall grain at once. They argue that the land has been accumulating moisture for centuries, and that it is useless to let it stand another year. They do not understand the fact that soil in its virgin condition is often compact and does not allow the water to penetrate readily. It is also covered with a growth of native vegetation which uses practically all the available moisture from the soil each year.

Before the first crop is planted on dry-land the soils should have stored in them a good supply of moisture. During seasons of exceptional precipitation, and in regions that are naturally favorable to dry-farming, it may be alright to plant a crop the same year as the first plowing, provided the plowing is done early in the season; but as a general thing, the safer practice for Utah dry-farmers is to plow the virgin soil at least one year before the first crop is planted. This enables the soil to store the rainfall of two seasons for the first crop, and also makes available a large amount of plant food.

In Utah, most of the dry-farm land is covered with brush of some kind, usually sagebrush. This has to be removed or broken down before the land can be plowed successfully. A great many
devices for clearing sagebrush have been tried, but none of them seem to be entirely satisfactory. The more complex machines cannot be afforded by the ordinary farmer, especially since their efficiency is a disputed question. It is probable that under usual conditions dragging the land three or four ways with heavy railroad rails, when the brush is dry, is about as satisfactory a method of clearing the land for a poor man as has yet been devised. This breaks off most of the brush and allows it to be gathered together in windrows where it can be burned.

![Fig. 8.—Sage brush of the type that indicates good dry-farm land.](image)

After the land has been cleared of brush, it should be given a deep, thorough plowing and allowed to remain over winter in the rough condition without being harrowed. This enables the winter precipitation to run readily into the soil, and the rough surface helps to hold the snow. In the spring before the weeds get well started, the land should be thoroughly harrowed to kill the young growth and prevent the escape of moisture stored in the sub-soil. The land should be tilled during the summer as often as necessary to keep the weeds in check and to preserve a mulch. The details of handling the soil are discussed more fully under cultural methods.

The essential principles that must be kept in mind in preparing virgin land for cropping are (1) that the sub-soil to a depth of a number of feet should be well supplied with moisture; and
(2) that the surface soil should be tilled in such a way that it furnishes a good seed bed.

V. DRY-FARM CROPS

The selection of good crops well-adapted to localities where they are to be raised is very essential to the success of dry-farming. The kind of crop is as important in dry-farm practice as the selection and preparation of the land. In all arid countries farming is, at best, somewhat difficult and in order to overcome the difficulties special care must be given to crop adaptation. In different sections the adaptation of crops should be carefully studied, and a selection made of those that have gained prominence after a trial over a number of years. In too many cases farmers have, without giving the question due consideration, selected the wrong crop for their locality, and thereby lost time and money. The law of supply and demand as well as marketing facilities should be considered in selecting the crop. Even when the best crops are selected for the different localities, the results obtained are often far from encouraging.

Wheat.

Wheat is the most important of the cereal crops of Utah. There are almost an infinite number of varieties, which may be classed as hard or soft, and as fall or spring.

Fall Varieties.

The hard red group is more widely grown in dry-farming because the yields are usually larger than those of the soft white group, which is not so popular. Turkey Red, including the Crimean group, and several other hard varieties have proved themselves adapted to most parts of the State, and have given promising results, both in milling and yielding qualities.

In the semi-hard group, Ghirka, Diehl, Mediterranean, and Odessa are the most important varieties that have given good results. The soft white group is widely used, and in some sections is chosen in preference to the hard red group; however, the yields are not so good as those obtained from the hard varieties. Koffoid, Lofthouse, Gold Coin or Forty-fold, White Club and White Australian are the most widely grown and also the most promising varieties of this group.
Spring Varieties.

When conditions are too extreme to allow fall planting, and when the operator neglects to prepare the seed bed in sufficient time for the plants to get a good start before growth is checked by continuous coolness or by freezing weather, the farmer resorts to spring crops, since these can be produced to better advantage than winter grains. Red Chaff, New Zealand, Sonora, and Defiance are prominent common varieties that have given good returns. The Marquis which is a hard wheat was recently introduced from Canada; this variety promises to become very important. In some sections it is grown as a winter variety.

The Spring durum, or macaroni wheat, has been grown successfully in different parts of the State, and out-yields most of the other spring varieties. As the demand for durum wheat is not so great as for the other varieties, the acreage devoted to its culture is limited. At the Nephi Experimental Farm the following varieties have given the best results: Kubanka, Velvet Don, Adjini, Pelissier, Kahla, and Mohamed ben Bachir.

Rye.

Both winter and spring varieties of rye are grown, but the commercial value of this crop is much lower than that of wheat. Rye, however, has a value in that it is a good live-stock feed and can be grown on land that refuses to successfully produce wheat, oats, or barley. It also seems to be more alkali-resistant than common wheat.

Oats.

Spring oats are grown more extensively than the winter varieties. This, however, may be due to the fact that spring varieties are better known. The Boswell winter oat, which is a leading winter variety, has given good results. Occasionally, however, this crop winter-kills. In early spring the crop is slow to develop, and as a result is often plowed under before it has a chance to show signs of further development; but usually if left, rapid growth takes place in early June.

Six varieties of spring oats: New Roosevelt, Swedish Select, Black American, Kherson, Sixty Day, and Giant Yellow have been tested for several years under dry-farm conditions with promising results. The Sixty Day oat matures considerably earlier than the
other varieties. The New Roosevelt produces well, and the grain is of high quality.

Barley.

Both winter and spring varieties of barley are grown, but this crop is not so extensively cultivated as wheat or oats. Utah and Tennessee winter barleys have given satisfactory results and are probably most widely known in the State. Bulgarian, Turkestan, Chevalier, Gatami, and other winter barleys are cultivated to some extent and have done well on the dry-farm.

Spring barleys grow well under conditions favoring the growth of spring wheat and oats. California Common, California Prolific, and Minnesota Spring are promising varieties that have produced well under dry-farm conditions.

Emmer.

Though Emmer has been cultivated profitably in Utah for more than twenty years, still it has not come to occupy an important place in the cropping systems of the State.

Both winter and spring varieties are grown, but the former is cultivated most extensively. Black Winter and Buffum’s Improved emmer have given very good returns under dry-farm conditions. These two varieties are very closely related. The White Spring variety has also yielded well. The Black Winter variety adapts itself to almost all conditions and is highly drought-resistant. For this reason, plant-breeders have used it in crossing with varieties of winter wheat.

Corn.

Corn is a profitable dry-farm crop, but frequent cultivations are necessary to conserve soil moisture and prevent the growth of weeds. The flint varieties usually give better returns on the dry-farm than do the dents. Jumbo flint and Australian flint have done best, while a number of other varieties have given satisfactory results.

Sorghums.

Both the grain and saccharine sorghums have been produced under dry-farming, but the grain varieties are probably the better. Dwarf Milo, Brown and White Koaliang, and Fetereta have been grown with varying degrees of success.
Alfalfa.

Alfalfa has been cultivated on the dry-farm for many years. Both hay and seed have been produced successfully by practicing the ordinary drill method. Planting in hills and rows, similar to planting corn and potatoes, which allows ample space for cultivation has been especially successful in seed production. The soil should be well cultivated and not cropped more than six or eight years in succession, until the field should be plowed and planted to a cereal or root crop in the rotation.

In order to get the best results in seed production, it is advisable in some sections to pasture or cut the first four to six inches of growth to stimulate an even second growth. In other areas the first crop is used for hay and the second for seed, although much seed is produced on the original spring growth. A strain of alfalfa has been developed in Utah, which has given good results on the dry-farm for both hay and seed production. A number of imported strains have also given fair results in arid regions. Cultivation of non-irrigated alfalfa should be continuous and thorough.
Potatoes.

The potato crop is more widely grown on the dry-farm than heretofore, and the yields are very satisfactory. Peerless, Pearl, Green Mountain, Early Bird, California Russett, Utah No. 1, Freeman, Early Eureka, and other varieties have given promising returns.

Peas.

The pea crop is coming into prominence and should be included in the list of crops for the dry-farm. For several years peas have been grown with success as a nurse crop and also in rotation with cereal crops. The Canadian field pea is no doubt the most widely known, while the Carleton, Early Britain, Yellow, and Marrowfat field peas all give good returns under dry-farm conditions. Peas are particularly well-adapted to cool climates.

Miscellaneous Crops.

There are several crops not yet mentioned which play a minor part in the list of profitable crops for the dry-farm. Grasses are grown to some extent, but on account of the sodding tendency it is difficult to cultivate old grass fields to conserve moisture. Brome-grass, western wheat-grass, tall meadow oat-grass, timothy, and Italian rye-grass have proved fairly satisfactory. Sudan grass, a new introduction into the United States
from the Sudan in Africa, promises to be important for the warmer dry-farm areas.

Clovers are grown for hay, for seed, and when plowed under as a green manure to enrich the soil. Sugar beets are grown, but the tonnage is not sufficient to warrant their extended culture. Mangel-wurzels, rape, vetch, cowpeas, and soybeans are grown for forage, and under favorable seasonal conditions the results have been flattering. From the experiments of the past few years, beans promise to be one of the most successful of the dry-farm crops. Tepary, White Flageolet, Choice Navy, White Wax, and White Marrow are all good varieties.

Flax is not grown so extensively on dry-farms of Utah as in some other states. This crop, however, promises to do well when spring conditions are favorable so there is moisture enough to germinate the seed and to enable the young plants to get a good start.

Trees, both for fruit and shade, may be grown without interfering with the general work or the cropping system on the dry-farm. Exceptionally favorable conditions are, however, usually necessary unless some irrigation may be practiced. These add so greatly to the beauty and comfort of the farm as to make it advisable to pump where possible. Bush fruits and vegetables, which lessen the cost of living, may also be raised under some conditions.

Quality of dry-farm crops.

It is generally conceded that dry-farm crops and their products, on account of their high nutritive value and protein content are better for man and beast than irrigated crops. Under a limited rainfall, cereal crops usually mature earlier, contain more gluten, and are of a higher weight to the bushel than grain raised under humid conditions.

VI. SEED SELECTION.

Experiments reported from different parts of the State indicate that, as a general rule, Turkey Red winter wheat is, on the whole, best adapted to Utah dry-farms. Millers throughout the country demand hard wheat on account of its high milling qualities, and it is also valuable because of its drouth-resisting power. In selecting seed a variety should be chosen that combines good quality with drouth resistance and high yield. A
number of good varieties have already been named, but no one of these is best for all conditions.

The characters that are desired in different varieties of crops should be carefully studied before the selection is made. Farmers generally understand that the best seed of each variety should be planted, but in actual practice they do not use as great care as they should to get the best seed. It is not practical for each farmer to maintain an extensive system for the breeding and improving of field crops, but he can afford to maintain a continuous seed plat. In doing this he should select the plants that are most desirable in every respect. These are kept separate from the main harvest and are planted the next year in a separate patch, which may vary in size according to the needs of the farmer. The next season more plants should be selected—preferably from the seed plat—and the remainder of the seed planted in a larger field. If this system is followed, the quality of the crop will be maintained at a high standard.

Table I shows the value of seed selected by the method just explained in comparison with ordinary seed taken from the bin. Two winter varieties were tested three years at the Nephi Experiment Farm. The increased yield in favor of the selected seed more than offsets the extra labor of selecting the plants.

TABLE I.—YIELD OF TURKEY RED AND ODESSA WHEAT FROM SELECTED AND FROM ORDINARY SEED.

<table>
<thead>
<tr>
<th></th>
<th>1912</th>
<th>1913</th>
<th>1914</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turkey, Selected</td>
<td>22.1</td>
<td>5.9</td>
<td>38.1</td>
<td>22</td>
</tr>
<tr>
<td>Turkey, Ordinary</td>
<td>7.0</td>
<td>1.1</td>
<td>38.9</td>
<td>16</td>
</tr>
<tr>
<td>Odessa, Selected</td>
<td>24.1</td>
<td>5.9</td>
<td>36.0</td>
<td>22</td>
</tr>
<tr>
<td>Odessa, Ordinary</td>
<td>17.8</td>
<td>2.2</td>
<td>29.0</td>
<td>16</td>
</tr>
</tbody>
</table>

Treatment of Seed.

In order to prevent loss from smut all wheat and oats should be treated before planting. The treatment recommended is to use one pound or one pint of formaldehyde solution (40 per cent strength, known as formalin) to forty or forty-five gallons of water. The solution may be placed in barrels and the grain, held in loosely woven bags or wire baskets, dipped into the solution where it is allowed to remain for ten minutes, and then drained and dried, after which it is ready to sow. The seed may also be spread on a canvas or board floor and the solution applied
with a sprinkler, or a mist spray, while the grain is being constantly turned so all the kernels become thoroughly wet.

A solution of bluestone, or copper sulphate, is made by dissolving one pound of bluestone, or blue vitriol, in four gallons of water. This is used in the same way as the formalin solution, but care should be taken that it is kept at a uniform density by thoroughly agitating before using. This solution must be handled in a wooden vessel for it attacks metal rather actively.

**VII. CULTURAL METHODS**

**Plowing.**

Deeper plowing should be practiced on practically all Utah dry-farms. This not only gives the water a better chance to enter the soil, but also gives roots a better opportunity to penetrate to lower soil layers. Land that has not been previously prepared with the intention of storing moisture in the sub-soil, seldom produces profitable crops. Plowing in the fall after harvest allows all the roughage, litter, and stubbles left on the field to be turned under; during the winter months and fallow period, considerable of this organic matter is decomposed and becomes available as plant food.

Sub-soiling has been advocated rather strongly in connection with dry-farming, but it is doubtful if the extra expense is justified by the increased returns. Table II which gives the amount of water in the soil when plowed 5 inches and 10 inches, and when sub-soiled, shows the best results for 10-inch plowing.

**TABLE II.—COMPARISON OF AMOUNT OF WATER IN SOIL WHEN PLOWED TO DIFFERENT DEPTHS. SIX YEARS RESULTS. NEPHI SUB-STATION.**

<table>
<thead>
<tr>
<th>Year</th>
<th>Sub-soiled Per cent Moisture</th>
<th>Tons of water to ten inches</th>
<th>Plowed Per cent Moisture</th>
<th>Tons of water to five inches</th>
<th>Plowed Per cent Moisture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1909</td>
<td>19.85</td>
<td>351</td>
<td>19.57</td>
<td>346</td>
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<td>1910</td>
<td>18.46</td>
<td>327</td>
<td>19.04</td>
<td>337</td>
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</tr>
<tr>
<td>1911</td>
<td>17.23</td>
<td>305</td>
<td>18.08</td>
<td>320</td>
<td>17.69</td>
</tr>
<tr>
<td>1912</td>
<td>17.01</td>
<td>301</td>
<td>16.69</td>
<td>295</td>
<td>18.10</td>
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<tr>
<td>1913</td>
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<td>311</td>
<td>18.61</td>
<td>329</td>
<td>16.23</td>
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<tr>
<td>1914</td>
<td>19.53</td>
<td>345</td>
<td>18.46</td>
<td>327</td>
<td>18.23</td>
</tr>
<tr>
<td>Average</td>
<td>18.27</td>
<td>323</td>
<td>18.41</td>
<td>326</td>
<td>17.93</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Sub-soiled Per cent Moisture</th>
<th>Tons of water to ten inches</th>
<th>Plowed Per cent Moisture</th>
<th>Tons of water to five inches</th>
<th>Plowed Per cent Moisture</th>
</tr>
</thead>
<tbody>
<tr>
<td>1909</td>
<td>19.85</td>
<td>351</td>
<td>19.57</td>
<td>346</td>
<td>19.21</td>
</tr>
<tr>
<td>1910</td>
<td>18.46</td>
<td>327</td>
<td>19.04</td>
<td>337</td>
<td>18.11</td>
</tr>
<tr>
<td>1911</td>
<td>17.23</td>
<td>305</td>
<td>18.08</td>
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<td>17.69</td>
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<tr>
<td>1912</td>
<td>17.01</td>
<td>301</td>
<td>16.69</td>
<td>295</td>
<td>18.10</td>
</tr>
<tr>
<td>1913</td>
<td>17.56</td>
<td>311</td>
<td>18.61</td>
<td>329</td>
<td>16.23</td>
</tr>
<tr>
<td>1914</td>
<td>19.53</td>
<td>345</td>
<td>18.46</td>
<td>327</td>
<td>18.23</td>
</tr>
<tr>
<td>Average</td>
<td>18.27</td>
<td>323</td>
<td>18.41</td>
<td>326</td>
<td>17.93</td>
</tr>
</tbody>
</table>
Spring plowing, which is sometimes done, usually makes the control of weeds easier than when the land is plowed in the fall. Plowing in the spring, however, is not to be recommended, since it does not favor the storage of winter precipitation, nor does it allow the weathering processes to act so readily on the soil. By the time the soil is sufficiently dry for plowing in the spring, there are other jobs that need immediate attention. It is usually a better farm practice, therefore, to take advantage of the slack season and plow in the fall, at the same time making possible the storage of a large part of winter precipitation in the soil.

Disking.

The disk is in general use on the dry-farm for the purpose of improving soil conditions. Disking stubble after the crop has been removed tends to stir up the soil and check weed growth. It may also tend to serve as a substitute for plowing when a cover crop, such as clover, peas, or vetch is planted as a green manure. Disking stubble immediately after harvest is often advisable since it breaks down the stubble and loosens the surface soil. This makes plowing easier and assists in covering all the organic matter. There are some farms where fall plowing would be nearly if not quite impossible without this practice.

The disk is also a useful implement in breaking up sod land which has been plowed. Such land is fairly filled with small roots, and the soil particles are held so tenaciously together by

Fig. 11.—Crust on fallow land broken with a disk.
them that the disk is about the only farm implement which will break up the structure.

The disking of fall-plowed land in the spring is practiced to a great extent with good success. Usually a heavy weed growth commences in the spring but if taken in time, this is easily checked. The disk harrow is a good implement for eradicating such weed growths and for keeping the soil in good tilth. Small disks on harrows for such work usually do better than large ones.

Harrowing which is second only to plowing in dry-farm operations, should be constant and thorough. During the fallow period the soil should be cultivated thoroughly in order to keep it in a friable condition. Such a practice not only prevents the loss of soil moisture from weed growth and from evaporation, but also insures a good seed bed.

When considerable precipitation occurs during the fallow period, as is the case in some sections, thorough tilling of the soil should be practiced throughout the season. A loose soil checks the run-off water and allows it to enter the soil where it is conserved for crop production. An examination of Table No. III and Figure No. 12 will make this point clear.

TABLE III.—EFFECT OF CULTIVATION ON MOISTURE IN FALLOW SOILS PLOWED IN THE FALL AT NEPHI SUB-STATION.

<table>
<thead>
<tr>
<th>Year</th>
<th>Cultivation Tons of water per acre</th>
<th>No Cultivation Tons of water per acre</th>
<th>Difference in tons of water per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per cent Moisture</td>
<td>337</td>
<td>Per cent Moisture</td>
</tr>
<tr>
<td>1909</td>
<td>19.07</td>
<td>17.13</td>
<td>258</td>
</tr>
<tr>
<td>1910</td>
<td>18.16</td>
<td>14.57</td>
<td>252</td>
</tr>
<tr>
<td>1911</td>
<td>17.47</td>
<td>14.21</td>
<td>230</td>
</tr>
<tr>
<td>1912</td>
<td>16.57</td>
<td>13.00</td>
<td>280</td>
</tr>
<tr>
<td>1913</td>
<td>17.50</td>
<td>15.82</td>
<td>266</td>
</tr>
<tr>
<td>1914</td>
<td>18.35</td>
<td>15.04</td>
<td>265</td>
</tr>
<tr>
<td>Average</td>
<td>17.85</td>
<td>14.96</td>
<td></td>
</tr>
</tbody>
</table>

Cultivation of crops in the spring, until the plants are four or five inches high, after which stage the soil is thoroughly shaded, has been demonstrated to be profitable, not only to the crop but to the soil. In the spring when the crops begin to grow the soil is usually crusted, so that the plants have difficulty in getting to the surface. Moreover this crust nearly always shrinks and cracks
thereby exposing not only the surface but the sub-soil to the forces of evaporation; which will be very active powers under these con-

ditions. Harrowing at the proper time is a great benefit. If however, the plants are firmly cemented within the surface-crusted soil, harrowing tends to pull them out of the ground or to break them off. This condition should be carefully watched, and avoided either by cultivating after a storm while the soil is still moist or by sloping the harrow teeth backward in such a way as to break the crusted condition without greatly disturbing the young plants.

In sections of light snowfall, heavy freezing of the ground generally occurs. The expansion caused by the action of frost is known as "heaving". This condition is injurious to plants because the roots are not able to stretch sufficiently to prevent being broken off. When this occurs, harrowing in the spring does more harm than good.

The spring-tooth harrow and various improved cultivators are used quite extensively on dry-farms for the eradication of weeds and for the cultivation of the soil. This harrow is
especially adapted to the cultivation of alfalfa fields, and serves very well for harrowing the fallow. This implement likewise improves the tilth of crusted and rain-beaten soil.

Cultivation of intertilled crops on the dry-farm is a good substitute for irrigation as applied in irrigated districts. When rains are frequent during the growing period, cultivations should be given after every storm that is large enough to destroy the surface mulch. The spike-tooth harrow is used to good advantage for this purpose until the crops get too large, after which time some kind of cultivator should be used. Thorough cultivation of intertilled crops keeps weeds in check and also maintains the soil in good tilth; both practices lessening the loss of soil moisture. In dry-farm operations where a system of fallowing is practiced, intertilled crops may be grown to good advantage. The hoe is used to some extent when horse power is not available, but this is expensive where a large area is operated.

The system of growing intertilled crops on the dry-farm is probably more profitable in districts where the rainfall is comparatively heavy during the growing period. Besides these crops can often be included in a rotation with profit on account of their benefit to the soil even where the direct financial return is not great.

Depth of Planting.

Under ordinary conditions three-inch planting has given best results for wheat, oats, barley, and emmer. Where the soil is sufficiently moist to insure good germination, and where heavy rainfall comes during the growing period, good results have been obtained from shallower planting. Such crops as alfalfa and grasses require shallow planting, but occasionally the soil is too dry to insure good germination unless the seed is planted deeper. A good practice to follow is to plant the seed as shallow as possible, and at the same time deeply enough to get it in moist soil so as to secure good germination. This will occasionally necessitate planting deeper than is usually desirable in a good seed bed.

Amount to plant.

The quantity of seed to plant to the acre on dry-farms depends largely upon the soil conditions and the amount of water
available. Three pecks, or forty-five pounds of wheat; six pecks, or forty-five pounds of oats and emmer; five pecks or sixty pounds of barley; four to eight pounds of alfalfa; and about fifteen pounds of seed of the ordinary grasses are probably average amounts to be planted. It will be noted that these quantities of seed are little more than half what would be recommended for irrigated land.

**Time to Plant.**

The time of planting is very important for dry-farm crops. Early planting both in spring and fall is usually to be recommended. This is especially important in the fall in order to get the crop well started before growth is checked by cold weather. For fall planting, September is probably the best, although in some instances crops may be planted as early as August, or as late as October.

**VIII. CROPPING SYSTEMS.**

Crops that fit the conditions in which they are to be grown should be chosen for the cropping system. Some of the conditions to be considered are the total rainfall and its distribution, the length of the growing period, the depth and character of the soil, the means of marketing the crops, and the preservation of the soil fertility. The continuous raising of a single crop, without any idea of adopting a rotation of any cropping system, has resulted in the ruin of much land in a number of dry-farm sections. The permanence of the dry-farming industry will depend on the establishment of adequate systems of cropping to meet the needs of the several dry-farm districts. No single system is suited to all conditions, but each locality must devise rotations suitable to its own needs.

Growing a grain crop in alternate rotation with an intertilled crop has been especially successful in sections where a greater part of the precipitation occurs during the growing period. In dry-farm sections where most of the precipitation falls during the winter months, alternate cropping and fallowing the land has been the most common practice. It seems necessary to store the precipitation of two years in order to get one successful crop. Table IV shows the relative value of continuous and alternate cropping.
TABLE IV.—EFFECT OF CONTINUOUS AND ALTERNATE CROPPING ON THE MOISTURE IN THE SOIL AND THE YIELD OF TURKEY RED WHEAT, NEPHI SUB-STATION.

<table>
<thead>
<tr>
<th>Year</th>
<th>Continuously Moisture Per cent Yield</th>
<th>Alternately Moisture Per cent Yield</th>
<th>Two in Three yrs. Moisture Per cent Yield</th>
<th>One in 3 yrs. Moisture Per cent Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per cent Yield</td>
<td>Per cent Yield</td>
<td>Per cent Yield</td>
<td>Per cent Yield</td>
</tr>
<tr>
<td>1908</td>
<td>12.04</td>
<td>13.4</td>
<td>12.88</td>
<td>32.7</td>
</tr>
<tr>
<td>1909</td>
<td>14.62</td>
<td>14.6</td>
<td>18.25</td>
<td>2.5</td>
</tr>
<tr>
<td>1910</td>
<td>13.32</td>
<td>7.8</td>
<td>15.90</td>
<td>9.9</td>
</tr>
<tr>
<td>1911</td>
<td>12.19</td>
<td>5.7</td>
<td>15.20</td>
<td>28.0</td>
</tr>
<tr>
<td>1912</td>
<td>13.14</td>
<td>6.0</td>
<td>14.28</td>
<td>4.8</td>
</tr>
<tr>
<td>1913</td>
<td>12.77</td>
<td>4.5</td>
<td>15.64</td>
<td>1.8</td>
</tr>
<tr>
<td>1914</td>
<td>13.53</td>
<td>24.0</td>
<td>16.08</td>
<td>41.0</td>
</tr>
<tr>
<td></td>
<td>Average.</td>
<td>13.09</td>
<td>10.85</td>
<td>15.46</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17.24</td>
<td>15.15</td>
<td>12.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>18.51</td>
<td>14.9</td>
</tr>
</tbody>
</table>

Figure 13 presents in graphic form the same material given in Table IV on the percentage of soil moisture and the yield of wheat. It will be noticed that the best results were obtained by alternate cropping, although the soil cropped but one year in three contained the most moisture, since it had not been removed by crops.

Definite cropping systems for dry-farms have not been well
worked out for all conditions, but it is hoped that more information will be available in the future. In the meantime, however, the importance of rotations should be kept in mind and every effort made to secure a diversity of crops for the dry-farm.

Dry-farm soils are usually deficient in nitrogen. This deficiency may be made up to some extent by the growing of leguminous crops such as clover, alfalfa, vetches, and peas, which serve the purpose of manure if plowed under. The soil must be well supplied with moisture, however, to insure rapid decay. By using such crops in a well-planned rotation the soil is left in good condition for the next crop. A difficulty, however, is that by growing these crops considerable of the soil moisture is used.

IX. STORAGE OF WATER IN THE SOIL

Success in dry-farming is dependent on the storage of water in the soil. Generally the normal precipitation in Utah is not sufficient during the growing period to mature crops without water having been previously stored.

Storage of water necessitates the incorporating of it into the soil and the preventing of its escape. Water may be lost by percolation to lower depths, by surface evaporation, by surface run-off, and by transpiration. Deep plowing, as a means of preventing loss of moisture, is the best method a farmer can practice since such plowing makes the soils more and more retentive after it has entered the soil. Where dry-farm soils are from six to ten feet deep, practically no water is lost by percolation.

Surface evaporation and run-off may be largely controlled by the farmer through cultivation and by other surface treatments. The transpiration by plants, however, is more difficult to influence; but even this loss can be lowered by selection of drought-resistant crops that are also high yielders and by making the soil more fertile.

The movement of water through the soil is governed by a number of conditions such as the size and arrangement of soil particles, the moisture content of the soil, and the amount of organic matter present. By tillage the farmer is able to increase the capacity of his soil for holding water; by shallow surface
tillage he is able to break this capillary connection with the surface, thus reducing evaporation; by making his land more fertile he is able to decrease the loss of water by transpiration; and by compacting the surface, making the soil grains touch each other more closely, he is able to establish capillary connection with the surface. For this very reason, therefore, surface packing is not advisable under arid conditions.

In sections where a limited amount of rainfall occurs, deep plowing and thorough cultivation are prerequisite to profitable crop production. Attention is called to Figure 14 showing the amount of water in the soil with different methods of plowing; also to Figure 12 showing the effect of cultivation on moisture in fallow soils.

**X. IRRIGATION AS A SUPPLEMENT TO DRY-FARMING**

Dry-farming and irrigation farming are usually considered as separate arts with but little relation to each other. As a matter of fact, they are closely related in many respects. Both
have for their aim the production of profitable crops in regions where the natural precipitation is not sufficient to carry on the most profitable agriculture by methods employed in humid regions. These two methods of agriculture are always carried on under the same climatic conditions, even though irrigation can be practiced in many places where dry-farming does not succeed. Dry-farming methods are employed over vast areas where there is not sufficient water for more than a very small amount of irrigation. They are sister arts, and like true sisters should be mutually helpful whenever possible. Just as sisters can often be of the greatest service to each other, so dry-farming and irrigation farming can attain their greatest success when each supplements the other.

Fig. 15.—A weedy fallow. Dry-farming cannot be successful unless weeds are kept under control.

Since the amount of water available for irrigation is only a fraction of the amount necessary to serve all the arid portions of the world, it is probable that dry-farming will reclaim many more acres than irrigation. It is fairly certain, however, that it can never be perfected to the extent of having as intense an agriculture as is found where irrigation water can be applied to the land. Thus the unirrigated areas of the arid regions will be called on to produce the cheaper crops that can be raised on a large scale, while the available irrigation water will be most profitably used on expensive crops raised by more intensive methods.
There are many ways in which irrigation water can be of the greatest help in developing and making profitable the vast areas of the world where dry-farming has been practiced and will in the future continue to be. Some of the uses of running water on the dry-farm are for culinary purposes and watering livestock; for help in raising garden or orchard; for application to a part of the field, at times, to make possible a greater diversity of crops; and finally for a small watering of the entire dry-farm to supplement a scant rainfall.

**Water for culinary purposes and livestock.**

In many dry-farm sections one of the greatest inconveniences is that all the water used in the home or by the stock has to be hauled long distances. This is often done at great expense when help is badly needed on the farm. Water obtained in this manner often become stale and warm and unfit for culinary purposes. It would be much more satisfactory if the dry-farm had in connection with it even a small stream of running water that could supply the needs of the household and barnyard.

**Raising a garden and orchard.**

On the ordinary dry-farm little opportunity is afforded for a garden or an orchard; hence, there is no chance for a desirable variety in the diet of the family. Most of the garden and orchard crops require, for a succulent growth, more water than is furnished by the rainfall of an arid region. If there were but a small quantity of water available for the irrigation of a limited area, it might be possible to raise sufficient vegetables and fruit for family use. This small addition would do much to make the dry-farm home more desirable than it would otherwise be.

Fruit trees have often been raised without irrigation in arid regions, but when they mature, it is difficult to get the fruit to remain on the trees till ripe because the soil moisture is greatly reduced before the end of the season. A single irrigation at a critical time will often save the fruit crop. Dry-farming methods could take the place of the earlier irrigations, but a small quantity of water applied as a supplement may make the difference between success and failure.
Water for part of the farm.

The dry-farmer is very fortunate if he can secure sufficient water to irrigate a small part of the field in addition to the garden. This makes it possible for him to greatly diversify his system of agriculture by producing many crops that he could not produce if depending entirely on the natural precipitation. On the irrigated portion, forage crops could be raised making it possible to extend the farm activities to include animal husbandry and dairying. Where this can be done, the farm income is made more certain and regular, at the same time part of the monotony of life on the dry-farm is reduced.

Some water for the entire farm.

Under certain conditions it is possible to secure sufficient water to give the dry-farm an irrigation or two to make up a deficiency in the rainfall. Investigations carried on at a number of the western Experiment Stations have demonstrated that the yields of crops can be very greatly increased by the addition of even a very small quantity of water at the right time. It has been foreibly brought out by workers at this Station that the greatest economy in the use of irrigation water is found where dry-farm methods are practiced and but a small quantity is used to supplement the natural precipitation.

A difficulty that is experienced in practice is that when any irrigation water whatever is applied the methods of moisture conservation necessary in dry-farming are likely to be abandoned with a resulting loss of water perhaps greater than has been added by irrigation. If, however, the same care is given after a little water is applied at a proper time, it will surely be a great benefit.

How to obtain irrigation water.

The water that is desirable to supplement dry-farming must be developed by a more careful use of the resources that are available. One region demands a certain method, while in another a different one must be resorted to. It is probable that one of the greatest sources of water will be by greater care of the supply now used on irrigated lands. This can be diverted to cover lands which are at present dry, but within reach of the canal.
Another source of increased water supply closely related to the first might be developed from the now-used streams by holding back their flood waters in the mountains by means of reservoirs and other devices, thereby saving the water to be delivered to crops when needed. The development of springs will also be important in some sections.

In many regions where dry-farming is practiced, there is considerable run-off from the surface at the time of heavy rains. If cisterns and reservoirs are made to catch this run-off, enough water may often be saved for the livestock and perhaps enough for a garden or orchard. Of course, the topography of the region determines the extent to which this method can be employed.

A method which is very promising in many regions is that of pumping water from wells with gasoline engines or electricity. Usually wells are rather deep in dry-farming regions, making it too expensive to pump water to irrigate the entire farm, but sufficient for the household and stock, as well as for a small area of land in addition, can often be obtained at small expense.

**XI. DRY-FARM EQUIPMENT.**

Profitable crops cannot be raised without special machinery to work the soil. At first it was not possible to get implements suited to the big-scale work of the dry-farm, but during late years many good machines for tilling the soil have been put on the market. Native land is usually covered with a growth of brush, which makes plowing difficult until it is removed. Several brush grubbers are on the market, but these are usually expensive and are often not suitable to the conditions. For a poor man a pair of heavy railroad rails are usually to be recommended to assist in removing brush.

The plow is the most important implement for dry-farm practice. Several types are on the market, so great care should be exercised in selecting the type suited to the conditions. The moldboard plow is preferred for breaking new land and it usually gives better results in general farming than other types. The disk plow is used to good advantage with some soils especially when a second plowing is required to kill weed growth. The sub-soil plow is used to stir the lower layers of soil. It is not in general use, however, as the expense of operation is often greater
than the increased results obtained. This is brought out in Table II.

The spike-tooth, the spring-tooth, and the disk harrow as well as various kinds of cultivators play an important part in dry-farm operations. These implements are absolutely necessary on every dry-farm.

Several makes of drills are in general use. The disk and the shoe drills are both used to good advantage, but the disk is preferred in sections where the soil is rather hard and rough, while the shoe has proved very satisfactory with a well prepared seed bed and soil in good tilth.

Traction engines have been used with fair success on some large dry-farms, but as a rule they have not been entirely successful in Utah. Great caution is advised in the purchase of these expensive machines without having some previous experience with them.

Several types of machines are used in harvesting and threshing. The header is in general use in almost every section for cutting grain. Combined harvesters are also used to good advantage on large farms. The binder, however, is very common on both dry and irrigated farms, and is preferred to other implements in harvesting such crops as oats and barley. A mower and rake are also necessary where hay is raised. Last, but not least, is the fanning mill used to secure clean seed which should be a part of every farmer's equipment.

XII. SUMMARY.

1. Dry-farming has been successfully practiced in parts of Utah for over forty years; and the yield of crops on some of the dry-farms has been steadily increasing. There are still millions of acres of virgin land in the State that can be profitably dry-farmed.

2. Great care in the selection of a farm and in following proper methods is absolutely necessary to the success of dry-farming. Haste and carelessness are responsible for numerous failures.

3. A dry-farm should not be located in a region having less than about twelve inches of rainfall in a year.

4. A dry-farm soil should be uniform and deep, and should
support a good growth of natural vegetation, preferably sagebrush.

5. New land should be plowed at least a year before the first dry-farm crop is planted.

6. Wheat is the most important dry-farm crop in Utah; but barley, oats, rye, potatoes, corn, peas, beans, alfalfa, the sorghums, and other crops have been raised with varying degrees of success.

7. The use of good seed is essential to the greatest success in dry-farming.

8. Success in dry-farming depends primarily on the storage in the soil of a large percentage of the rainfall.

9. In Utah, it is usually necessary to leave the soil uncropped during each alternate year because the moisture of two seasons is needed for one crop.

10. Deep plowing, usually in the fall, and thorough tillage of the soil are necessary to conserve moisture.

11. Weeds use large quantities of moisture. Special care should be taken, therefore, to prevent their growth during the fallow year.

12. Irrigation, in many sections, is a valuable supplement to dry-farming.

13. Under proper conditions dry-farming is one of the most profitable kinds of agriculture, but unless these conditions exist it cannot be made to pay.