PARSONS ON DRY FARMING

E. R. PARSONS

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A Collection of Articles Written by E. R. Parsons and Published in The Dakota Farmer, Aberdeen, S. D., during 1912 and 1913

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Introduction

TO produce profitable crops under a limited rainfall, it becomes necessary for the farmer to possess a thorough knowledge of the principles and practices of soil moisture conservation. A very large portion of The Dakota Farmer Empire comes under the classification of semi-arid land.

That a wider distribution may be given of facts relating to the actual practices of dry farming and the compiling of these in more convenient form is the reason for the publication of this book. It is a reprint of a series of articles written by Mr. E. R. Parsons for The Dakota Farmer and published in its columns during 1912 and 1913.

For many years The Dakota Farmer has been keenly on the lookout for men who have most successfully overcome the obstacles of farming in dry areas. There are many of these men. They have blazed the way to profitable farming and better living in all the great northwest. It is for us to follow where they lead.

Of these men, Mr. Parsons, by virtue of his splendid scientific training, his tenacity of purpose and his forty years of practical experience stands out as the premier exponent of practical dry farming in America.

With his knowledge of the subject is coupled the gift to impart it to others in a style as entertaining as it is characteristic.

Mr. Parsons is an original thinker and investigator. He has not been bound by precedent or hoary theories. He has successfully worked out the problems of profitable crop production on his own lands and under an average annual precipitation of fifteen inches.

The reader will be interested in knowing more of the man Parsons and what he has accomplished. He was born in England in 1854. His education was principally along scientific lines. A few years after leaving college he went to South Africa and engaged in dry farming. The precipitation ran from 10 to 20 inches. He found the settlers raising small crops on 4- and 5-inch plowing, using four oxen to the plow. Parsons put eight oxen on his plow and began to raise double what the neighbors did. The principal crops at that time were oats for horse forage, cut in the dough, barley, potatoes and corn fodder.

But let Parsons tell his own story. He can do it better than we can:

"I purchased some lucern seed (alfalfa) to test it for that country. Nobody there could get a stand, but it was raised in the wet districts farther north. I found the trouble was shallow plowing. Put ten oxen onto the plow, got it down 10 inches, obtained a magnificent stand of alfalfa first try. Got a herd of mixed stock for dairy farming and sold milk for 25 cents a quart bottle. The natives which could be hired for a few dollars a month, and all the corn meal they could eat, did all the work carrying the milk and other produce to town in baskets and selling it. Did well there until 1877, when I sold out and volunteered for the Zulu war.

"Left for England after the war and came to Colorado in 1880. Rented a ranch to try out dry farming, raised large crops of seed corn and navy beans, which brought the top of the market in Denver. Could not persuade anyone they were raised without irrigation, either had to shut up or lose my reputation for veracity.

"In 1883 took a trip to California, found them raising fruit and everything on 20 inches of rainfall and sometimes only 10.

"Noted that the Portugese and Italians were planting grape vine cuttings on the dry hillsides of Los Angeles where they considered themselves lucky if they got 13 inches of rainfall. These cuttings were

2 feet long and put down in the ground until only about 3 inches stuck out. After the wet season was over nearly 90 per cent would be growing vines. Some of these vineyards are still alive and producing four to five tons per acre. Came back to Colorado in 1886, and homesteaded. This was the beginning of my Parker ranch 20 miles south of Denver. Purchased a big team in Denver and started to break land 9 inches deep, sometimes getting over only one-half an acre a day.

Deep Plowing Was a Joke.

"Neighbors would come over and josh about it, which I rather enjoyed, leading them on and asking their opinion about things.

"Next year the joke was all on my side, for the corn grew 8 feet high and the grain outweighed the fodder, something which none of them had ever seen before. The wheat was 5 feet high and some of the rye 7. That fall I bought cows and hogs, also some stands of bees, and the next spring I put in five acres of alfalfa.

Hogs and Poultry Paid.

"I had already planted a family orchard, giving everything plenty of room. The hogs ran to the rye stacks all winter and with the help of a little corn and alfalfa I was enabled to sell hogs every month or so at from 10 to 20 dollars apiece. We fed the chickens all the wheat they could eat at night and mashes in the morning; hauling bones off the prairie for dessert. The chickens (about 100) almost paid the grocery bill. There were no creameries in those days, so we sold our butter in town. We had the usual luck with stock; the horses were struck by lightning, the best cows would hunt mud holes and commit suicide, the calves would try to get colic or diarrhea, the bees would get foul brood and the cat would have fits. As soon as we began to feed the cows alfalfa their suicidal tendencies vanished, they began to have more confidence in dry ranching, raised calves and attended strictly to business. We cleaned out the foul brood and shut the cat up during the grasshopper season.

"I often regretted I did not keep books, but we were absolutely too busy; but every time we went to town we took in a load of hogs or butter or honey or veal or something, and every few years we bought some land until our ranch grew from 160 acres to 1200.

Developed a High Altitude Corn.

"I took the White Australian seed corn as a basis, crossing it gradually with large white eastern varieties, using them as the male parent until I had an acclimated, high altitude corn which would go with deep plowing over 40 bushels to the acre at 6,000 feet. I was always able to sell all the seed of this corn I could raise. I am not raising this for seed now; I have too many other things to do, but if anyone wishes to try it they can obtain it from its chief Colorado raiser, Frank J. Kohler, (altitude 6,300 feet).

Kept Increasing Alfalfa Area.

"Every few years I planted more and more alfalfa. I raise it on sandy loam, adobe and gulch sand. I took the precaution, however, to fertilize the gulch sand with about fifty loads of manure to the acre before planting; this paid me well, because nothing else would grow on it, but the alfalfa took hold, got down to moisture after three years, and converted a desolate sand bar into a beautiful field. The larger part of my alfalfa is grown, however, on hillsides above dry clay reefs with no water at 100 feet that we know of.

Planted Commercial Orchard.

"In 1894 I commenced planting an orchard, and have now nearly twenty acres in apples, cherries, plums and currants. I have never seen the sour cherries grow better or bear handsomer fruit anywhere.

The profits from this orchard, with every other year or more a bad year climatically, runs into thousands. I never ship anything, the people come from four counties to get the fruit to put up for winter. Mr. N. P. Gould, Pomologist U. S. Department of Agriculture, writes of my Ben Davis apples: 'Incidentally I am glad to state that these apples are very interesting to us. I do not know that I have seen fully matured Ben Davis apples from a dry land orchard before. I had rather expected that grown under dry land conditions, the texture would be more woody and the flavor even flatter than is common with the Ben Davis, but this does not appear to be the case. The texture compares favorably with apples grown in definitely recognized Ben Davis regions, and as to dessert quality, as already indicated, it seems to me that it is unusually high for the variety.'

Forty Years of Dry Farming Experience.

"Thus far I have been dry farming for close on forty years; it is the only branch of agriculture that I have got to the bottom of, and that only by persistent work and experiment in odd moments and Sundays. The most useful implement I have for this purpose is the soil auger. With this I can bring up a sample of dirt from any depth in the subsoil and by making note of the percentage of moisture at different depths, can ascertain what amount of water is held by any cubic block of land; what the moisture is doing; whether it is moving or standing still; increasing or fading away. By comparing the moisture in a vacant block with that in a block occupied by a tree I can calculate the amount used up by that tree; the same method can be applied to any plant or crop.

Always An Investigator.

"I also find a microscope a very useful adjunct for research work. My operations have all been based on a knowledge of what is and what isn't; have never been much impressed by fads or the systems of men who guess at things. A single dry year does not bother me at all, but a second one does. My worst year was in 1911, with only 6 inches of moisture. The year before was 9 and the roots left only about 8 to 10% of moisture in the subsoil. In order to get the late corn and sorghum started in 1911 we had to plow furrows down to the damp soil and plant in the bottom of them. The feed crops averaged only about a ton to the acre; the neighbors had nothing. The principal factors in my success have been my complete mastery of the art of plowing, and the interest I take naturally in all branches of science. Beside my ranch at Parker, Colorado, I have two dry farms in California, where I find that infinite variety in the vegetable world so fascinating to the student of nature."

Mr. Parsons is an active member of the International Dry Farming Congress, the Royal Agricultural Society of England and the National Geographical Society, Washington, D. C.

E. R. Parsons.

Parsons on Dry Farming

CHAPTER I

Deep Plowing

THERE is only one solution to the problem of how to dry farm and always raise crops. Plow deep. Those who go under are the ones who persist in dodging the issue.

There is no doubt that crops can be made in wet years by plowing only four or five inches, packing the ground solid and then cultivating all summer to loosen it up again, but does it pay?

Those who indulge in this style of surface farming usually pay out in dry years every cent they make in wet years for the grocery bill and to keep their stock alive. Intensive cultivation may to some extent counteract the evil effects of shallow plowing but can never fully compensate for lack of deep tilling at the start.

For instance, a crop of corn planted in land plowed 12 inches deep and cultivated two or three times will yield twice as much as the one planted on a 6-inch seed bed and cultivated all summer. This is where economy comes in, for every operation in the field is so much to the expense account.

When a farmer defends shallow plowing, his own field will always give him away, for the best grain, the finest corn, is always found where the plow went in the deepest or the prairie dogs did some subsoiling.

Why should a man spade his garden a foot deep and then go out and plow 6 inches? Can anybody explain the philosophy of such proceedings?

When a gardener wishes to raise a large plant in the green-house, would he put it in a 6-inch pot or a 3-inch?

We have never been able yet to find a soil or a country where deep plowing did not pay, and the drier the country the deeper the plowing. How is it that an old soil in use for hundreds of years in Belgium, France, England, Germany and other countries can double and treble our average yield per acre? The principal reason is because they plow from 9 to 15 and sometimes 20 inches, while we think we are doing wonders if we scratch the ground 6.

One of our great sugar factories pondered over the fact that while Germany and Hungary were raising from 15 to 30 tons of beets to the acre, our farmers with virgin soil and abundance of irrigation were raising only 10. They sent all the way to Germany for an expert, and when he arrived this is what he said: "How can you expect to raise a 12-inch beet on 6-inch plowing?"

Why is Standard So Low?

Why is our standard of plowing so low? Because those farmers who first went west from the coast states lost the art of plowing in the middle west where crops planted in the richest of virgin soil and rained on every few days would grow whether the land was plowed or not. Therefore to find good plowing we must hark back to the old New England states where the conditions were not so favorable. Connecticut is probably the deepest plowing state of any and having a cool climate is by nature not as well adapted to corn raising as any of the central or river states; yet according to the U. S. Department of Agriculture we find that last year it averaged per acre, 48 bushels of corn, against 14 in Kansas, 26 in Missouri, and so on. In 1910, these averages were 53 for Connecticut, 19 for Kansas, 33 for Missouri.

Wherever deep plowing is introduced into the west, we always meet with the same objections as fantastic as they are absurd. It will ruin the soil. Our subsoil is too hard. We have to plow it very carefully and very shallow to get the Indian out of the soil. (This from Montana.) The subsoil is no good, it comes up in lumps. If we plow it, we can never pack it and if we pack it we can never plow it. The subsoil is sour and poisonous and hard besides; better leave it alone. We have a different soil in this state, you dare not plow it deep.

This last objection, of course, is the greatest nonsense of all. No state or district has a monopoly of any wonderful variety of soil that cannot be plowed. As the Germans say, a soil which will not respond to deep plowing is not an agricultural soil and we might add to this certainly not a dry farm soil. There is no such body of soil that anyone in the west has ever heard of yet, although a few, very few, such streaks might possibly be found where the joint clay or gopher clay comes too close to the surface, but such odds and ends can be left for pasture.

Soils Ready for the Plow.

Since the great water period thousands or millions of years ago which provided the foundation for our upper layers, the soil has thoroughly dried out and the space originally occupied by water is now taken up by air, which sometimes represents as much as 50% of the bulk in a cube of dirt. The consequence is our soils are sweet and ready for the plow; we have no sour lands, no wildness or Indian to get out. This is an imported idea belonging to the waterlogged lands of the eastern states and has no place whatever in dry farming. Some of the largest crops I have ever made, and I have made many in the last 35 years, have come off sod broken a foot deep. The upper layers of our soils in Dakota and other adjoining states are many of them glacial drift which is fair soil and can be plowed any depth, but above these boulder clays we sometimes have a foot or two or even more of humus wash loam, the richest and finest of soil for small grain and corn. These soils can be plowed any depth; if the subsoil is hard, a subsoiler can be used, but get down at any cost; it will pay in the end. Deep tilling, turning up and working the whole thing, is better than plowing a few inches and then subsoiling, but subsoiling will open up the soil for the deep tilling later on, in case of a very hard subsoil.

As we go farther west we encounter the light ash and lava soils as they are called and wherever there is a good growth of sage brush cleared off, these soils are immensely rich.

Many a man is grubbing along on such a soil plowing 3 or 4 inches and half starving his family because he does not know that if he understood the value of plowing he could raise 60 bushels to the acre instead of 10 in wet years and probably a good 25 in dry years.

Some of the adobe soils are rich; some are not; it depends on their origin. The farmers call everything sticky, adobe or gumbo. The joint clays which sometimes come to the surface belong to the cretaceous period when there was little or no organic matter to afford humus and are consequently of little value for agriculture. The glacial boulder clays, however, out of which much of our reddish brown and chocolate-colored adobes seemed to be formed, are rich in mineral plant food and when the sod is plowed under deep will contain a fair amount of humus.

These lands need deep plowing in the fall to allow of weathering, deep breaking to save the humus and plenty of working. Corn and grain crops do not grow as high as they will on a sandy loam, but the corn is usually larger and the grain heads heavier. The best and most practical method of tilling these lands will be given in an article later on. Many failures in deep plowing occur from plowing when the ground is half dry and then planting it before it has a chance to settle and acquire moisture. In dry farming, land should never be planted immediately after plowing.

If you do not give the rains a chance to drive the air out, the crop will burn out every time. If you cannot plow in the fall, then plow your corn and sorghum land in March and your winter wheat land in May, then no packing will be necessary except in the seed row and the press drill or planter wheels will do that. The idea of buying an expensive packer when nature can do it for you is absurd. On the other hand if you are bound to plant the land anyway as soon as plowed, then harrow and disc alternately until fairly solid, but it is always advisable to fallow the land if only for a few weeks or a month or two. In dry farming we need air on the surface for weathering soil and developing plant food, but not in the ground, for a dry over aerated soil is the most deadly enemy of dry farm crops. A good rule to follow if you raise small grain is this: Plow in the fall for spring grain and in the spring for fall grain.

For corn, plow deep in the fall and leave it rough to weather and accumulate moisture all winter, then work up deep and thoroughly before listing or planting in May or June.

Little Excuse for Poor Plowing.

There is really very little excuse for poor plowing in the west for our soils are admirably adapted to deep plowing.

The glacial epoch has given us an extra layer of good soil exactly where we most need it and for this reason the great bulk of our land can be plowed almost any depth which is the most important factor in dry farming. The secret of obtaining a heavy crop on dry farm land is to root the crops deeply in the subsoil. This can be done in one way only, by keeping it wet enough so that the roots can enter. If you plow 10 or 12 inches the adjoining subsoil will be better protected and much damper than when you plow only 6 inches; in fact, on many shallow plowed fields the roots never get below the top 6 inches and the crop amounts to little or nothing.

In deep ground the subsoil is always in condition, for under a seed bed, 10 or 12 inches deep, the evaporation is almost nil, and once the water is absorbed into the subsoil it stays there until the crops take it out. If every dry farmer in the west were to increase his depth of plowing from 6 to 12 inches, the railroads could not haul the stuff.

CHAPTER II

Reasons for Deep Plowing

DRY farming has been styled "The Conservation of Moisture." It should be styled "The Accumulation and Conservation of Moisture."

You cannot conserve anything that you do not have, therefore the prevention of run-off, puddles and surface evaporation generally, together with the preparation of the ground for quick absorption may be termed the accumulation of moisture, the first half of dry farming.

The principal factor in accumulation is deep plowing; the principal factor in conservation is mulching.

Why does deep plowing accumulate more moisture than shallow plowing? For the same reason that a barrel will catch more rain than a bucket; the receptacle is larger—12 inches will hold twice as much water as 6.

The subsoil takes water very slowly because it is solid and compact and the interstitial spaces are small, therefore, during heavy rains, as soon as the plowed soil is soaked down to the subsoil it begins to run off or to form puddles. This is what we want to prevent, and there is only one way to do it. Plow deeper and increase the depth of the seed bed.

It might be argued that there is seldom enough moisture to waterlog a field plowed 6 inches, but we find that nearly every year there is one such instance and sometimes two. When a field already contains moisture from previous showers, the torrential rains of July and August will very soon soak it to the limit, and the same may be said of the soft, wet snows of spring, when the precipitation of four or five weeks has been known to amount to 4 or 5 inches which would very easily soak up a seed bed of 15 inches.

We cannot afford to lose a single inch of this water; for the rest of the year may be dry! Thus we see that this function of deep plowed land, that of quickly absorbing torrential rains or excessive snowfall is a most important one in dry farming.

Moisture in Subsoil.

Another function of the deeply plowed seed bed never touched upon by agriculturists is that of acting as a mulch to the subsoil. The old idea that plants lived on the top soil and the moisture came up out of the subsoil to supply their roots has long since been abandoned by sane agriculturists, for we find that water in the subsoil stays where it is put, and that under 12-inch plowing, after making several hundred tests in all varieties of soil, the loss seldom exceeds 1% a month and in some cases is almost nil. This, of course, is on fallow land with no crop growing.

In order to be thoroughly satisfied on these points, the farmer should make his own experiments and not trust to the say-so of anyone who may be quoting some laboratory experiments which do not apply, or some out-of-date college book of the days of Johnston and Liebig.

It is a very simple matter with a ground auger or even a pick and shovel to get a sample of soil at any time at any depth, then weigh it and bake the moisture out of it and weigh it again. The difference in weight will, of course, show the amount of moisture it originally contained, and by making different tests at separate dates at a variety of depths, a correct estimate can be formed of what the water in the soil is doing. The farmer will soon find out that one experiment in the field is worth a dozen in the laboratory, and by this means will become acquainted with natural physics at first hand.

The advantage of deep plowing to mulch the subsoil is found in the fact that when it is kept moist and in proper condition, the roots of crops will go into it from two to ten feet.

From tests in the field we find that the normal length of the roots of small grain is from 3 to 4 feet, of corn from 3 to 10 feet, but in 6-inch plowing, in a dry year, when the subsoil is not properly mulched, the roots do not penetrate it at all, for it is too dry, and we often have this spectacle of man trying to raise a crop on 6 inches which needs 4 feet. Is it any wonder he fails?

Packing will not help him, cultivating day and night and Sundays will not help him, and the only satisfaction he can get is to join the chorus of wails about the crust under the mulch, which, by the way, cannot injure his crops if he plows deeply and maintains a loose mulch on the surface.

The surface farmer who plows 6 inches or less and pulls off medium crops in wet years by dint of excessive cultivation, and then pays out in the dry years what he made in the wet ones, often wonders why a few inches of rain makes such a tremendous difference to him, while the crops of his neighbor, who plows 10 or 12 inches, always seem to be good.

The reason is, in a wet year his subsoil becomes wet enough for crops, for the roots to penetrate; in a dry it does not; hence the difference, but the subsoil of his neighbor, who plows deep, is always in condition, for it carries over moisture from one year to another.

From the foregoing it can be readily understood that dry farm crops are made largely from the subsoils.

Extraordinary, you say. This gives me altogether a new idea of dry farming, but are our subsoils good enough for this?

Subsoils Rich.

They most assuredly are, for in western America we find the best and richest subsoils almost of the world, and they can be worked by any man, or at least by any man that is a man, for with our 20th century implements we can break up anything but solid rock.

Hardness in a subsoil does not necessarily imply lack of fertility; shale and argillaceous deposits formed from pre-historic river mud, when fined down and weathered, may raise magnificent crops. Without deep plowing it is almost impossible to raise satisfactory crops in a dry year, and without crops in a dry year it is foolish to imagine that dry farming can be made to pay. The philosophy of it is this: When the farmer plows 6 inches and cultivates his row-crops 3 inches deep, he has then 3 inches of mulch, leaving 3 for the surface roots. After three or four weeks dry weather the mulch becomes dried out, then if the drouth continues, the dirt under the mulch begins to dry and form a crust. Then comes the question, how much soil is left for surface roots?

The plowing was 6 inches, take off 3 for the mulch and 1 or 2 more for the crust under the mulch. This leaves about 1 inch for the surface roots. Is it any wonder crops dry out with 6-inch plowing?

The farmer, however, who plows 12 inches will have seven inches left for the roots of his crop, and under these conditions no drouth can crowd them, for after the first 5 inches are dry, the drouth line deepens very slowly indeed.

Deep Seed Bed Important.

A deep seed bed for the surface roots is a most important item in raising a heavy crop. The surface, or rather the top foot contains, as a rule, most of the humus, and it is the humus which supplies a large proportion of ready-made plant food, therefore, a deep seed bed means quick and luxuriant growth. Another point we must not lose sight of is that the quicker the roots get down the less danger there is from drouth injury.

The tap roots which go into the subsoil supply the plant with moisture and mineral plant food, but the surface roots which exploit the seed bed find all elements necessary to plant life, particularly the nitrogen, which, owing to the habits of the nitrifying bacteria is found principally in the top 8 or 9 inches. Land plowed 10 or 12 inches holds its tilth much longer than shallow land, and is often mellow and loose on the surface at maturing time which is a tremendous advantage at the period of the plumping up and filling of grain.

Shallow land settles, runs together, cracks and bakes very easily, requiring constant cultivation to keep it in condition, and many a crop planted on such land which made vigorous growth at the start and promised a heavy yield dried up instead of ripening, yielding a little shriveled grain in the place of a bountiful harvest.

After land has been plowed deeply for several seasons, one dry year makes very little difference to crops, but a second, following on the heels of the first, is a more or less serious matter, and may cut the crops a fourth or a half, according to the quantity of moisture it has been possible to store in the subsoil.

Two of the driest consecutive years ever experienced on my ranch were 1893-94. In 1893 our crops were very little below the average. In the spring of 1894 the surface was so dry it was almost impossible to start the crops, and in order to get down to moist dirt we had to plow out the corn rows and plant the corn (after soaking it) in the wet subsoil at the bottom of the furrow. By this means we obtained a good stand, and with about 2½ inches precipitation during the growing season we made a fair crop, but not so good as 1893.

There was a little snow which raised the moisture content of the upper subsoil to about 15% by planting time, but below this there was 3 feet of moist subsoil containing from 10% to 12% only.

The 2½ inches of rainfall came in moderate showers without reaching the subsoil, but was of great advantage in moistening up the seed bed.

Thus we see that without the subsoil moisture accumulated and conserved by deep plowing, it would have been utterly impossible to have raised any corn in that year; in fact, none was raised by the old methods of plowing 6 or 7 inches.

Dry Farming Not New.

Although dry farming is supposed to be a new thing, it is actually as old as the earth, and in western America dates back to the original settlers. There are many who have made their fortunes at it, although few hear about them, but these men were all and every one deep plowers. One of the most noted of these is G. L. Farrel, of Smithfield, Utah, who, on an average precipitation of 15 inches, raises 400 acres of wheat every year which goes from 40 to 45 bushels per acre.

There are hundreds of others around him, who, on the same land, raise 20, but he plows 9 inches and subsoils down to 15, while they plow 6 or 7, put in a much larger acreage and in dry years get nothing.

In Montana we have Norman Holden, of Dillon, who plows from 8 to 12 inches and raises 250 bushels of potatoes to the acre.

In the dry streak in the south last year a boy succeeded in raising 202 bushels of corn to the acre on old played-out land by plowing 20 inches deep and fertilizing in the row.

CHAPTER III

Practical Work of Deep Plowing

WHAT is the best depth to plow? This depends somewhat on the soil and climate, but largely on the economic status of the ranch in question. Taking a medium heavy loam soil as the standard, the difference between 6-inch plowing and 10 will usually double the crop.

The difference is more marked, as a rule, in heavy soil. After a depth of 10 inches has been reached there is still a gain in yield for every extra inch up to 20, but the question is, will it pay for the extra work?

This is a problem the individual farmer must settle for himself. When he has horses eating their heads off in the barn it will pay every time to double up and plow as deeply as possible, but if on the other hand he has to borrow or hire to plow an extra inch or two the returns might not show much of a profit above the outlay.

The only experience worth accepting in a case of this sort is that of farmers who have made good at dry farming, raised their families and have cash in the bank; in other words, those who have made money at it or are well fixed.

We find that those who plow 8 or 9 inches are better fixed and have nicer homes than those who plow 5 or 6, but those who have made a minimum of 9 or 10 are sending their sons and daughters to college, and driving fine horses and taking trips.

Our opinion is that the small farmer should make 10 inches the minimum depth. The reason is this: This depth can be reached with nearly every walking plow of good make by taking off the gauge wheel and setting her down to the beam, with three heavy horses not less than eleven or twelve hundred each, doing the plowing. For this work a 12-inch plow can be used or even a 14-inch provided the horses are heavy enough or the soil easy.

The difference between riding on a sulky and walking in the furrow may mean to the farmer the difference between poverty and comfort. It is the work of almost one horse to haul the farmer around, and this means at least a loss of about 3 inches on the plowing. This 3 inches may cause a reduction in the crop of 10 or more bushels per acre. The price of 10 or more bushels on every acre of an ordinary farm would not only take the owner to New York for instance for a trip; but also hire him taxicabs to ride about in while he is there. The farmer who owns hundreds of acres of plowed land, has plenty of horses or owns an engine is in quite a different class to the small farmer who owns only two or three horses, for he can place in the hands of his help all the power they can handle, but he also must determine for himself his economic co-efficient in soil inches. This can be very easily done by keeping record of different fields plowed variable depths with the expense account attached thereto, and will soon show the most profitable depth to plow. This may be 10, 16 or even 20 inches. Some tremendous crops of corn running as high as 200 bushels to the acre have been raised on 20-inch plowing, but we have no record of the expenses.

One or More Operations?

The next question we have to consider is: Does it pay better to plow the whole depth in one operation or to plow first and follow in the same furrow with a subsoiler? In ordinary good deep western soil, if the same piece of land is plowed say 15 or 16 inches with a deep tilling machine, it will yield more to the acre than when plowed say 9 inches and subsoiled down to 15 or 16.

For the same reason four horses on a deep tilling machine or plow doing fair work for their weight will raise more to the acre (other things being equal) than two of the same horses plowing and two following with a subsoiler.

Another point in economy: The two teams need two drivers, necessitating the cost of an extra man for subsoiling. It may be said, however, in favor of subsoiling that sometimes a very tough hard-pan may necessitate something of the kind the first year of deep plowing. These considerations and many others can best be determined by the man behind the plow. In order to increase the depth of plowing is it better to go down an inch or so at a time or to plow the whole extra depth at once?

Provided the soil is all right, the sooner the farmer gets the benefit of his work the better for him. What sense is there in waiting five years to get down 5 inches when he can get down in one? The trouble is many of our farmers do not want to do their work until the last minute and then plant immediately. This should never be done in dry farming. If the subsoil is hard and refractory it must be given time to mellow down, and nothing is better for this than the winter-fallow. During an average winter the lumps will all soak up with the melting snows, then freeze and crumble with the thaw, leaving perhaps a few clods for the disc to dispose of which is easily done after a spring storm. In the meantime the lower layers are settling with every storm and the deepest kind of plowing will be ready for crops by planting time unless the winter is very dry.

All land should, as far as possible, be plowed ahead of time and fallowed for several months, but a month or a week is better than nothing. By doing this we not only accumulate moisture, but the land packs itself which is immensely superior to artificial packing; for all rollers and packers, whether you call them subsurface packers or not, must of necessity pack the surface more than the lower layers, but when nature does the packing the deepest dirt packs the first on account of the weight above it; in other words the packer packs from the surface down; nature packs from the bottom up.

Handling Sod Lands.

The immediate success of the new settler often depends on the way he handles his sod. If he breaks his land grandfather's way, plows it 2 or 3 inches and runs a slanted harrow over it, unless the season is very favorable, he will soon become disgusted with the results, for planting seed on chunks of shallow plowed sod is very much like trying to raise a crop on a rag-carpet.

In our western country we usually have a good sod full of decayed roots, the humus of ages. On this humus mainly depends the chance of raising successive grain crops without the expense of purchasing fertilizers; it is the life of the soil. Should we foolishly and recklessly, deliberately destroy it, by exposing it to the sun and the oxygen of the atmosphere which burn it up and dissipate it into gases, in order to make the work a little easier for ourselves?

Can any sane man doubt that the only proper way to handle this sod, this humus, nature's gift to the farmer, is to plow it under deep where it can rot in a moist environment, and where every particle of it can be absorbed and conserved by the soil for future use?

In the fall of 1887, on my Colorado ranch, we plowed ten acres of sod 10 inches deep, left it rough all winter to fill up with moisture, and disced and harrowed it in the spring until the surface was as fine as old land. On this we planted corn, cultivated three times keeping every weed out. The yield was a ton and a half of fodder to the acre and thirty-three bushels of corn.

A neighbor prepared a piece of the same soil in the spring, breaking his sod grandfather's way; he could not cultivate it on account of the chunks; his yield was a quarter of a ton of fodder and three bushels of corn.

The second year we cross plowed, again 10 inches deep, discing thoroughly to disintegrate the last of the sod. Our yield that year was forty-seven bushels. Our neighbor of the slanted harrow got down 5 inches, managed to cultivate six times against our three and raised eleven bushels.

How Often to Plow Deep.

Is it necessary to plow deeply every year? It certainly pays, but it is better to do so every once in a while than not at all. Some recommend deep plowing for a corn crop and then in the fall running in a crop of winter wheat on the stubble. This, of course, is gambling with nature; sometimes in wet years a catch crop can be made, but more often not; but if hay is needed, rye can be planted in this manner with every chance of success. It can also be planted for a fertilizer and plowed under in the spring.

Implements to Use.

The greatest implement for dry farmers and one which in time will place this industry on a permanently profitable basis is the deep tilling machine invented by Geo. Spalding. It plows from 10 to 20 inches deep, one disc working behind the other, both in a single furrow tearing the sod to pieces and burying it out of sight, leaving a beautiful smooth seed bed with the humus at just the right depth for the roots. This implement, of course, requires plenty of horsepower, which the small farmer does not always possess, but any ordinary walking plow properly pointed, with the gauge wheel left off, will go down 10 inches if properly maneuvered; such as the Canton, Governor, Oliver, John Deere and others.

The ordinary disc plow may also be used in conjunction with these as an emergency plow, especially when adobe or ordinary soils are too wet or too dry for good work by the moldboard, but in no case should land be plowed continually with the single disc plow, for this implement scatters the dirt too much without completely turning it and for this reason if the soil is to be kept in the best condition, must be alternated with the moldboard.

Deep vs. Shallow Plowing.

Deep plowing is the key to success in dry farming, and every failure may be attributed mainly to shallow plowing, and the complete evidence of this is to be found in the history of the early settlers, for not a single deep plower ever went broke or left the country.

There is no doubt that deep plowing is to some extent hard work, but not nearly so hard as imagination represents it to be, and much the easier in the end than surface farming which depletes the soil, wears out the farmer and gets nowhere.

Simplified Dry Farming.

There are hundreds of dry farmers or rather thousands who plow about 6 inches, pack, disc, harrow and cultivate day and night and Sundays and lose every year in wasted effort enough to keep themselves and families in luxury the year round.

The dry farmer has no expensive outlay, no water to pay for, no ditches to mend, no rheumatism to doctor, yet he gets irrigation prices for everything he raises; surely he can afford to plow and even if he is short of horses, he can double up with a neighbor to the advantage of both.

We are glad to see that deep tillage is taking hold in the west and several colonies and communities which have adopted it in Colorado, notably at Cathan and Limon, are raising the finest of crops even in dry years, are becoming prosperous, making money and booming their land values in consequence.

In a recent article coming to our notice, Mr. Cyril Hopkins advances the theory that if we plow deep and raise big crops we will exhaust the soil. We would be glad if this gentleman would tell us what to do with the soil except raise crops on it; he reminds us of the man who owned a gold mine and was afraid to develop it for fear of running out of gold.

These western soils are rich in mineral plant food, in fact we might say are made up of nothing else, and when we consider that the mineral part of plants and vegetation generally is only about 6% of the whole, it is ridiculous to speak about using up the soil in this generation, so long as we conserve the humus—this is the point, and the only method ever discovered of doing this is deep plowing; plowing under the sod as deeply as possible at the start and after that as much of the stubble as can be afforded. The abandoned farms of New England which everyone has heard about were ruined by shallow plowing, surface farming using up the humus, raising a little stuff on the cream of the soil without adequate plowing; soil robbery; burning the candle at both ends.

These farms are now being sought after by modern agriculturists and redeemed by deep plowing and the introduction of humus, and some of them are in better condition today than ever.

Shallow plowing destroys fertility by burning up the humus which is found mostly on or near the surface. Deep plowing preserves the soil by burying the humus where its gases are absorbed by the dirt instead of the atmosphere and thereby conserved.

CHAPTER IV

For and Against Deep Plowing

IN western America we call anything over 8 inches deep plowing, but in other agricultural countries of the world this is just ordinary plowing. Eugene Grubb, after he made a tour of agricultural Europe, came back and said that Americans were the worst farmers in the world.

In England, France and Germany, there are 700 different soils; they plow about 9 to 10 inches all soils, and every once in a while 16 to 20 inches, especially in the fall for weathering purposes, and, of course, they beat us all to pieces on acre crop averages.

Prof. Tower reported that on the Island of Jersey 600 bushels of potatoes to the acre was quite an ordinary crop; they are usually planted on land plowed 20 inches deep.

The French dry farmers in Algiers have discovered that the only way to obtain a stand of alfalfa is to plow about 20 inches.

Experiences in Many Soils and Climes.

Besides dry farming in Colorado for over thirty years, I own and operate two dry fruit farms in California, have dry farmed in South Africa, have studied in English and French colleges and am acquainted personally and practically with soil of every variety of texture.

Much of the soil of my Colorado ranch is of exactly the same quality as that found in Dakota, Montana, Wyoming, Nebraska, Kansas and New Mexico. The foundation or subsoil is of a yellowish clay containing a fair amount of lime, potash, and phosphates; the surface is the usual loam containing plenty of humus, when the sod is properly handled.

Deep Tilling or Not.

Regarding deep plowing with the Spalding plow, one well known writer in the northwest in reference to Dakota soils, says: "There cannot anyone convince me for a minute that one can expect a crop of small grain following the use of this implement, tilling to a depth of 10 inches, either in a normal fall or in the spring before the crop is planted." "The soil has not weight enough and does not get moisture enough to settle fast enough."

In direct contradiction to this we have the experience of Professor Waldron of Dickinson, N. D., who told us at the Dry Farming Congress that out of several plantings, on land which was packed and on soil which was not packed at all, the difference was very slight; but what there was, was in favor of the unpacked land.

We also have the evidence of Prof. Alvin Keyser of the Agricultural College of Colorado. This gentleman is about the most conservative Professor in Colorado and not at all biased in favor of deep plowing. He says: "The field was plowed around the outside with the Spalding deep tilling machine. A strip in the center and a strip on the same field at one side was plowed with our usual plows. The yield of oats on the land plowed with the Spalding deep tilling machine lacked only a few bushels of being twice as great as that on the side strip plowed with the ordinary plow. This work was all done on land which was in very bad condition because of a lack of rotation and manure. The benefits this particular season from deep plowing are much greater than we had anticipated; no doubt better because of the run-down condition of the soil."

This is a typical case of deep plowing, helping run-down light soil, the very soil this writer is so afraid of.

Professor Ten Eyck says: "1911 was one of the driest years ever experienced in Kansas." "That while the shallow plowed land yielded a little over four bushels of wheat per acre, early deep plowing gave thirty-eight." As far as packing is concerned the craze is beginning to wear itself out; many of our friends are dropping the packer and using the disc instead. Every time the land is gone over with any implement it develops more plant food and benefits the coming crop whether it is a harrow or a packer or a disc. At the same time it is quite possible for the land to be over aerated, especially when planted immediately after plowing.

Seed Bed Deeper Than Plowing.

When land is plowed 10 inches deep, it will create a seed bed about 15 inches in depth. When this is properly disced and harrowed it will be about 14 inches deep; if allowed to fallow for two or three months with an average precipitation of an inch a month, it will sink down and settle about another inch, and will then be 13 inches deep. It is then approaching its best physical condition and the crop can be planted. As the crop grows and more rain comes it reaches its best physical condition at 12 inches, just about in time to mature the crop, which gives us the highest possible yield. Now supposing the farmer packs the soil at the start, reducing it from 15 inches to 13; a month or two's fallowing settles it down to 12; then he plants it. He obtains the best physical condition of the soil at the start instead of at maturing time for by that time the soil is overpacked a little too hard, liable to form a crust under the mulch and the yield is not what it promised to be, for over-growth at the start is very poor preparation for drouth at the finish.

Nature's Soil Packing Best.

Another point: Nature's packing is better than artificial, because the soil is packed (by its weight) from the bottom up while artificial packing is from the top down.

However, I would say this in further answer: If Dakota possesses a special soil, to be found nowhere else in the world, specially donated by an all wise providence to the people of this state, which is very rich, but in which the necessary packing quality was overlooked, then by all means get a packer and pack it.

Campbell once said words to this effect: "If you plow over 6 or 7 inches, the packer will not pack it."

We know it; some packers on the market are at their best, playthings; but there are rollers and packers which will pack anything on earth, and we would say, rather than lose thousands of dollars a year and wear out the richness and germinating qualities of your fine top soil by shallow plowing, if you find it necessary, invest a few dollars in an implement which will do the work.

Experience Not on Lava Ash Soils.

Another leading writer in Dakota says of our deep plowing methods: "In the main, Parsons is right; but am afraid he is farming on some of these lava or ash soils. He hits straight from the shoulder," etc. The necessary momentum to hit straight from the shoulder is acquired from dollars in the pocket and experience in the upper story. As regards the ash soils they are about the only kind I have never farmed, but have raised crops on heavier soils and lighter soils. The lightest and also the heaviest respond readily to deep plowing. Harris B. Wasson, of North Dakota, says: "Plow deep everywhere." There you have it in a nut shell. We have plenty of friends, however, in Montana and Idaho and their verdict of these soils also: "Every inch counts."

Many Being Converted to Deep Plowing Idea.

Prof. Thatcher agrees thoroughly with us in plowing the sod deep to save the humus and Prof. Palmer is urging 8-inch plowing as the minimum. The indications are that everyone will be plowing deeply in a few years, but why lose money in the meantime?

Campbell also is becoming interested. His paper says: "Heavy soils, especially the clays that have been plowed from 4 to 6 inches deep, will be benefitted by a deep plowing—a plowing that will turn up the soil from a depth of 8 to 10 inches." He also says: "Lighter soils that solidify readily will stand deep tillage, providing a subsurface packer is used to firm the root bed."

This is much better than the antiquated notions about plowing which Campbell seemed to have adopted into his system.

The idea of plowing sod 3 or 4 inches, running a slanted harrow over it, backsetting it the next year and tumbling it about in the sun for a couple of seasons cannot by any stretch of the imagination be called agriculture. Six-inch plowing is not much better, but his recent utterance as quoted above is a subject for congratulation, as it seems to mark an advance all along the line.

Our Subsoils Are Rich.

Some farmers object to good plowing because they say their subsoils are not rich enough. This is an absurd argument, especially in a wheat-raising country. The particular quality which differentiates a wheat-raising country from any other is the adaptability of its subsoils to this branch of farming. No wheat can be raised by 6-inch plowing or any kind of plowing, if the subsoil is not right. Wheat is a deep feeder, the roots going four feet into the subsoil, and any man who can raise even ten bushels to the acre and says his subsoil is poor is talking nonsense.

The reason Dakota is such a fine wheat-raising state is owing almost entirely to the quality of its subsoils. If you raise wheat, then your subsoil contains lime, potash and phosphorus, besides nitrogen, for wherever there is lime (calcium) and humus there is nitrogen, for lime conserves nitrogen. Now we get back to breaking sod again. The sod is the principal source of humus for the new settler, and it is money in the bank if properly handled, plowed deep and buried in the subsoil.

Get the Sod Next to Clay.

The best place for the sod is next the clay where the lime can conserve the nitrogen. According to the soil specialists, the nitric acid as soon as it is formed by the nitrifying bacteria, attacks the lime and becomes nitrate of calcium thus forming a most important soluble element for the soil solution. Where there is no lime present to take up the nitric acid as soon as formed, the bacteria die in their own juice, are killed off by the nitric acid, and the nitrifying process slows down or comes to a full stop. For this reason wherever we find that nitrogenous crops flourish such as wheat and alfalfa, we know about what to expect in the subsoil. It is altogether an old-fashioned delusion to imagine that crops are made by the seed bed; in dry farming especially, the subsoil has most to do with it.

"Dry Farming" More Than "Good Farming."

Our agricultural friends who come from the humid states often tell us that dry farming is nothing but progressive farming; good farming. This is a serious misconception of the true facts; dry farming is a branch by itself, a new agriculture. The soil and water physics are entirely different, for speaking broadly, dry farming is done on capillary water, while humid farming is done on free water. In dry farming the water is always going down, and the top drying out, while in humid farming the free water is always helping out the surface moisture and supplying the roots in the seed bed. Therefore we find it impossible to raise profitable crops without the right subsoil conditions, and these conditions can be obtained by one method only, that of deep plowing.

The Greatest American Agriculturist.

If we judge the man by his works, the system by results, then Dr. Seaman Knapp was the greatest of all American agriculturists. He regenerated the agriculture of the south, made two bales of cotton grow where one grew before, and doubled every crop of corn and cane, by his deep plowing methods. He says: "Many trials made in a great variety of soils show that the cost of plowing 10 inches deep is on an average about 50 cents more per acre than ordinary plowing."

"There is no doubt whatever that breaking and pulverizing to a depth of 8 to 10 or 12 inches and adding humus is economical."

Some of the advantages he enumerates are that it provides more food because it increases the chemical action and multiplies bacterial life in a larger body of soil.

It stores more moisture and loses its moisture less rapidly on account of its cooler, lower strata and the presence of more humus, (the plowed under soil).

It increases the root structure.

It enables the plant to root deeper and find permanent moisture in the subsoil.

Government Should Demonstrate Deep Plowing.

We have been working in Colorado for deep plowing for a number of years and are getting results. W. S. Pershing, mayor of Limon, says: "The Federal Government could do five times as much good for the farmers if, instead of building reservoirs, they would plow 100 acres a foot deep in each section and turn it over to the new settlers."

Limon is being built up by dry farming with deep plowing; hundreds of acres are plowed from 9 inches to a foot deep. The soil is heavy, the crops enormous. Pershing will give particulars. At Calhan following our deep plowing methods they are raising, at an altitude of 6,300 feet, forty to sixty bushels of corn; sixty to seventy bushels of oats, and forty bushels of wheat. One of the principal farmers and deep plowers is Frank J. Kohler. At Burlington they are raising alfalfa all over the prairie. If you plow shallow it dies out. If you plow deep it stays.

On Utah soil we have G. L. Farrel dry farming for half a century at Smithfield. He tells us: "I never did very much at dry farming until one day about forty years ago, my plow broke; I started to mend it at home, but when we got through we found it had a terrible down pull, plowing some 9 to 11 inches. It was too far to the blacksmith's, so we went ahead and plowed that depth."

The crop grown on that piece of land was a revelation to him; he now plows deep and plants thin, raising every year from forty-five to fifty bushels winter wheat per acre.

We could fill this paper a hundred times over every month with statistics on deep plowing, but if any reader wishes to be convinced, why not try it out, if only on a quarter of an acre?

I persuaded a neighbor to do this once and he planted it to beans. I saw him the other day. He said: "Parsons, we are still living off those beans you persuaded me to plant ten years ago."

CHAPTER V

Cultivating and Mulching

IN order to thoroughly appreciate the necessity of stirring the soil to create a mulch to conserve moisture, some knowledge of soil physics over and above what is found in our college books is necessary.

Dry farming is in its infancy as far as its literature is concerned, for none of the great agriculturists of former days considered it worth while, and nearly everything in print concerns humid agriculture, and has little or no bearing on dry farming.

The great difference between the two is, roughly speaking, that dry farming is done on capillary water, while humid farming is done on free water. Wherever the subsoil is dry the free water is forever percolating down and becoming capillary (film) water. In the humid states the chronic condition of the subsoil is wet, not dry, and the consequence is that the precipitation enters the interstitial spaces between the granules which are already covered with film water, and remains there more or less as free water until used up by the roots.

If you try it out in the soil, or watch the film moisture on the granules through a glass tube with a microscope, you will soon find out that the difference between these two forms of soil moisture is that free water will rise or try to rise to the surface; film water will not.

In the year book of the Department of Agriculture for 1908, a writer on soil says, that the soil granules hold the film water with a tenacity equal in strength to a pressure of several hundred pounds to the square inch.

Cultivation.

On the humid farm they cultivate as they say, to cut off capillarity to make the interstitial spaces so large that the free water cannot rise to the surface and there evaporate. On the dry farm this is only one of the many reasons for cultivating to form a mulch. The most important one is to destroy the continuity of the earth pores or fissures through which the air circulates and causes evaporation. These diminutive cracks or fissures zigzag in every direction starting on the surface as the ground begins to dry out, and going deeper and deeper every day with the drouth. When the soil contains no free water the interstitial spaces are occupied by air which, of course, is saturated and will carry water out of the soil if allowed to escape.

This air moves in the soil more than most people think. In disinfecting soil, vineyards for instance, to kill the phylloxera they place half an ounce of carbon bisulphide in the center of each cubic block of earth 3 feet thick by 3 feet wide. This kills everything living within said block inside of 48 hours. It makes no difference how hard the earth is so long as the interstitial spaces are not blocked with free water.

The deeper the mulch the better, of course, for conserving moisture; but here we run up against another proposition, the accumulation of moisture. The more quickly we can receive the water and allow it to percolate downwards and become film water the better we can save it. The sum of all our experiences gathered in this matter is that the best all round mulch for accumulating and conserving is about 3 inches deep and a rough distinctly furrowed mulch is much better than a smooth one.

The Dust Mulch.

In a country where there is a rainy season a deep smooth dust mulch is of course preferable where the object is to conserve the moisture through a long dry spell until the rains begin again, but in our country where moisture may fall any minute we have to be prepared for it, for if it is allowed to remain on the surface as free water a large proportion of it is lost by capillarity, and evaporation, especially where the land is plowed shallow and overpacked. It is true that a smooth mulch offers less surface for evaporation purposes than a rough one, but it forms more mud, catches the water in pools, does not absorb it as quickly, bakes and cracks and forms a crust more easily.

Cultivation must always be performed across the slope so that the cultivator furrows impede the run-off and allow the water to soak in between them, leaving the top of the little furrows sometimes almost dry, which prevent the baking afterwards so common to smooth land. Another point is, that furrowed land, however small the furrows, will always remain looser than smooth land, because during the drying out process the tension is different at the top than it is at the bottom of the furrow, and this diverse action helps to keep the soil loose. A most important function of the cultivator is to develop mineral plant food. Every working of the soil results, as a rule, in increased yield. The particles of earth are disintegrated by attrition exposing molecules of different elements to the acids of the soil, and decomposing humus, which thus becomes converted into soluble salts available for the soil solution.

We have an almost unlimited supply of mineral plant food, but not so the humus, and there can be no question but that cultivation uses it up. There is no way around it, the best we can do is to plow deep, thus mixing a large amount of soil with it and thereby reducing the loss to the lowest possible limit.

At the same time attention might be called to the fact that shallow plowing followed by intensive cultivation is the most destructive method known of depleting the soil of humus. The truth of the matter is that shallow plowing provides such a small reserve of moisture for a crop that if a few drops of water are lost, a single cultivation to break the crust neglected, disaster is liable to result. The crops are made, such as they are, by cultivation instead of plowing which is not only unscientific but absolutely unprofitable.

In cultivating the fallow when the land is deeply plowed it is not at all necessary to break every crust that forms, for light rains and even winds often come and fill up the little cracks or pores before they have extended an inch below the surface. Our experience in this matter is that a fallow field cultivated enough to keep the weeds out, will, if properly plowed at the start, contain at the end of the season nearly twice as much moisture as the one plowed shallow and intensively cultivated. When a drouth ensues after wet weather the free water in the top 6 inches keeps coming to the surface and that part of it which has not become capillary water is used up fighting the drouth for the top inch.

The Crust Under the Mulch.

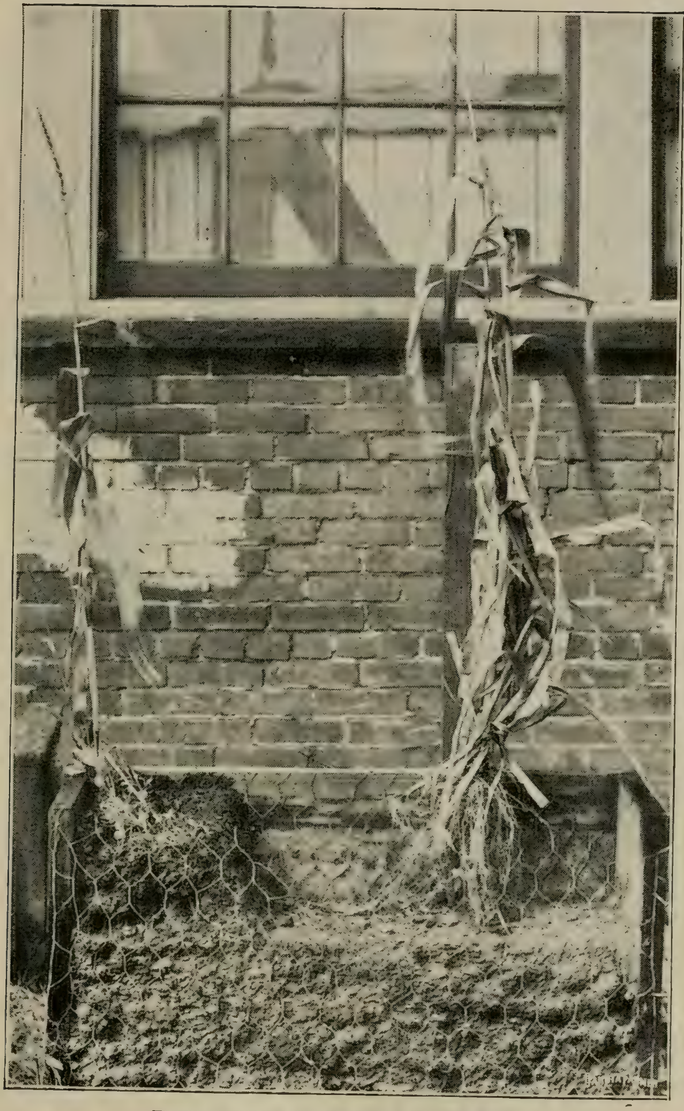
When all the free water has been evaporated the top inch commences to dry out, the capillary or film water remaining in place; in a week or so another inch will have gone dry, but the soil underneath if tested where no crop is growing will be found as wet as ever, showing that the moisture is not rising into the dry ground above. When the top 3 inches consisting of the mulch have dried out, a crust commences to be formed by the drouth under the mulch. Now before going any further we may point out that if the old theory of film or capillary water rising to the surface were correct, it would be impossible for the top to dry out until the water in the subsoil was more or less used up; but instead of this what do we find? That the top dries out and the water in the subsoil is as plentiful as at the beginning of the drouth. A few simple experiments will convince anyone, who wants to be convinced, of these facts. At this stage of the game we find the crops in this position. The 3-inch mulch is dry, the ground under the mulch is beginning to dry and the surface roots are becoming crowded. Suppose the seed bed is only 5 inches, we can see what a fix the farmer is in! Suppose the seed bed is 10 or 12 inches and the drouth getting down at the rate of an inch a month, which field would a man put his money in to raise the best crop? These questions, of course, answer themselves, but there is another question: Will any variety of cultivation help the situation when this crust forms under the mulch?

No; the roots are right there in the crust and if the farmer tears up the crust he tears up the roots. Another point: There is no more loss of moisture with this crust under the mulch than there was before, provided the mulch above the crust has been kept in good tilth. We have often sampled the soil under the crust and found it carrying its full quota of film water —for its variety of soil, about 15% to 17%.

This crust under the mulch is not dreaded by deep plowers; it is only one of the many symptoms of dry weather; let it form if it wants to, and remember this: The fifth and sixth inches dry out very slowly indeed, if they ever dry out at all, and all the roots the farmer can get established by deep plowing below the sixth inch are going to stand in any drouth.

Implements for Cultivating.

The best implement for cultivating corn is the regular six-bladed cultivator running three blades on each side of the row. There is no object in cultivating deep at the start, and shallow later on, for it is better that all the cultivation be about 3 inches, not allowing



Root Growth in Shallow Seed Bed.

Soil below the top two inches is hard and cannot easily be penetrated by the roots—a condition that exists in shallow-tilled fields.

any roots above this depth on account of drouth. If there is any slope the rows should always run across it, not up and down with it, and if the crop is planted in hills and worked both ways, the up and down rows should be done first and the field finished across the slope, as this helps to hold the run-off until it can soak in. Cultivation does not create moisture; it only helps to conserve it, therefore in a long period of drouth when the mulch is in perfect tilth it does more harm than good to keep on cultivating, for it makes a dust mulch which clogs the interstitial spaces and when the rain does come it cannot get down and the corn goes on wilting as before. Everything on the dry farm should be cultivated as far as possible, the theory being that the farmer should break every crust that forms, but with deep plowing if enough cultivation is supplied to keep all the weeds down and out, a good crop will result. Trees are easy to grow if they are planted in rows and cultivated, but when pot holed in hard ground they usually die.

The safest implement to cultivate alfalfa with is the harrow, but when planted in rows can be worked with the ordinary cultivator. Winter wheat and small grain can be cultivated with the harrow and when it is too high for that with the weeder which is a machine built on the principle of the hay rake. Small grain should not be worked until thoroughly stooled, and we seldom harrow winter wheat until the spring.

The most critical time usually for all crops is when the spring rains have ceased and the showers of summer have not begun; then is the time to look for a drouth, and put a good mulch on everything.

When I came to the west many years ago, people used to tell me it was nothing but a cow country, fit only for cattle and coyotes; yet everywhere we could see weeds growing from 2 to 6 feet high; the prairie was dotted with beautiful wild flowers and wild fruit even could be had for the hunting. They called it a desert, the arid lands, the cattle country, yet the only thing that ever made this a near truth was man's incompetency. The very fact of our having to reckon with weeds shows the absurdity of such ideas. Fifteen inches of precipitation is plenty for the farmer who understands his business, and even then he has to fight the weed-growth in order to make his crops. Weeds have to be exterminated by cultivation, but it is poor economy to be everlastingly weeding a corn patch when a little care at the start would have saved all the trouble. When the sod is first plowed there are very few weeds. The grass should be turned under deep so that every one can be cultivated out, and one man with a hoe can destroy every one going to seed on ten acres in a day. If this is kept up the land never becomes weedy. When land is plowed ahead of time, as it always should be, nearly all the weeds can be cultivated out before ever planting the crop. Crops which favor weeds should be rotated with crops like winter rye which kill them out. On a weedy ranch they have not only this season's weeds to attend to which sprout on the surface, but the weeds which will come next year from the seed plowed under this year. The time to kill weeds by cultivation is when they are coming through, and corn can be cultivated with the harrow before it comes up by removing a few teeth in order to miss the rows; but a thick planting for fodder may be harrowed regardless.

The Summer-Fallow.

Intensive cultivation of the summer-fallow is not to be recommended, especially with the harrow, for it creates a dust mulch, uses up too much humus and does not conserve as much moisture as enough rough cultivation with a disc or corn cultivator to keep the weeds out. The best implement to use on the summer-fallow for catching quick rains is the disc. The land should be disced and cross-disced without lapping. This leaves the field in checkers or squares the width of the disc hollow in the middle and high at the edges, which if properly done will hold an inch of rain if it comes in twenty minutes.

The disc is also invaluable for terracing an orchard on a side hill, hollowing out the rows across the slope to catch the water and prevent run off.

The plow and even the road grader can be used for such work, and I look forward to the time when our hills will be planted to shade trees and our mountains reforested by just such a method. In cultivating as well as in plowing and packing we must always have an eye to the accumulation of moisture as well as its conservation.

CHAPTER VI

Subsoil Moisture

IT is quite true that some confusion does exist in dry farm physics in the minds of nearly everybody interested. There are several reasons for this. One is that the professors and farmers speak different languages. Another is that professors and books do not always agree among themselves; the science of today is not always the science of tomorrow, and the most beautiful theories in the world may go to pieces in the face of some ugly little fact which bobs up sometimes many years after, with seemingly no other reason except to upset and confuse theory with practice.

Humid Soil Physics Do Not Apply to Dry Soils.

Another and more pertinent reason is that our dry farm soil physics have never been properly elucidated and printed in book form and our agriculturists are still floundering in the free water physics of the humid states which do not apply to our western dry farm soils and subsoils.

I am endeavoring in this article to show from my long experience in dry soils wherein this difference lies; but without any explanation whatever, we can all see that the action of capillarity in a dry soil must be something totally and radically different from the action of free water applied to soil granules in a glass tube from a basin of water.

These college experiments are, of course, of value to humid farmers and irrigators; but the dry farmers are not farming over a tight subsoil much less over water.

We may avoid some of the confusion by dividing soil water into two classes: that which moves and that which does not move, but here the professor might step in again and say there is no water which does not move, and technically speaking, he would be correct; but a movement of water in the soil a tenth of an inch, the thickening of a film a thousandth part of an inch though interesting to the professor might not affect the dry farmers' crops a particle; for what he wants to know is: not what capillarity can do when supported by free water as Professor Hutton tells us; but what happens to film water in our dry farm subsoils when capillary action stops or becomes dormant, for this is the chronic or natural condition of our subsoils.

Eastern Teaching Incorrect.

When agriculturists come here from the east they forget that their soils are wet; ours are dry. The first thing they tell us is this: Water soaks into the soil and becomes capillary water; after a while as soon as the top begins to dry out it begins to work up to the surface again.

This is correct of the east, but correct only in a very limited way of the west and absolutely incorrect as applied to the subsoil and the seed bed in dry farming.

In the wet states there is always water down below; therefore the water cannot get down into dry ground where capillary action peters out for want of moisture; but capillary action does cease for another reason altogether. When all the granules hold a big film of moisture of equal size, capillary action ceases because equilibrium is established.

We must notice that in this case in wet countries, action has ceased for the time being, with plenty of water on hand (the water that moves). Now when dry weather comes and upsets the equilibrium by drying out the surface this more or less loose water starts by capillary action moving back to the surface again.

Dry Land Subsoils Naturally Dry.

On the dry ranch conditions are altogether different; our subsoil is naturally dry, not wet. When water falls on it, it spreads out and down until it is all used up; it has become film water; it can never move again by capillary action until more water comes, as the farmer would say, "It is too dry to move." Therefore, when the top begins to dry out this water stays where it is in the subsoil. Now we can perceive what a profound difference this fact makes between the relation of the seed bed and the subsoil, and we can begin to understand that although the seed bed is almost dry in some years we can yet make a crop on the subsoil.

Capillary Action Stops Absolutely.

Dr. Widtsoe in his book says that when a certain stage of dryness is reached capillary action stops absolutely.

Dr. Alway, of Nebraska, says when capillarity comes to a standstill for want of water, the agency which moves water to the surface is distillation.

Professor Snyder, of North Platte, says his soils will hold from 14% to 17% of water after all action and drainage have ceased.

The writer by repeated experiment in the subsoil itself knows that his soil will hold against capillarity and gravity with dry dirt all around it from 13% to 18%.

The percentage depends largely on the soil, humus soil and clay soils holding more than sandy loams.

In order to be exact I would like to say here that I do not intend to infer that capillary action is absolutely dormant at these percentages; but that any slight movement of moisture of a tenth or an eighth of an inch for instance obtained by intense pressure, does not in any way affect the general relation of top soil and subsoil as regards moisture.

Film Moisture Strongly Held.

In speaking of film moisture a writer of the Department of Agriculture says in the year book for 1908, that this moisture is held by the soil granules with a tenacity equal to many hundred pounds of pressure to the square inch.

The only agency which can move it is evaporation. Much of the confusion which arises in the minds of ordinary laymen with regard to these matters is the result of teachers of agriculture who have had no experience in dry farm soils presenting us with the soil physics of the wet states which so far are the only physics to be found in book form.

We can imagine what a dry farmer who is accustomed to the dry subsoils of New Mexico and Texas, thinks when some young fellow gets up on the platform and tells him that the water is always coming up from his subsoil traveling in a stream from one granule to another until it reaches the surface. If this were a fact we would need no dry farming instructions and no literature. The truth is, that in times of drouth the seed bed may completely dry out while the subsoil is carrying a full complement of film water up to the limit where active capillarity and drainage cease, namely from 14 to 17% in ordinary soils.

Next I will proceed to show how a man working in the soil becomes acquainted with these facts.

In 1893 and '94 we had two very dry years, the precipitation being somewhere about 9 and 8 inches respectively.

Experiments in Dry Orchard.

In '93 I started preparing land for my orchard by deep plowing and fallowing. At the end of the season the moisture had penetrated to a depth of 3 feet. When the water was going down, the top and even the subsoil sometimes carried as much as 25%. After the water came to a standstill two or three days after a storm the water in the subsoil always measured the same, 17% (in clay loam).

Every time it rained the same thing happened; the moisture went deeper but the percentage remained the same. Now why was this? Simply because capillary action and the pull of gravity came to a standstill when that particular soil carried less than 17% of moisture. Then when a rain came and started action again it did not increase the percentage but went on and down deeper and deeper into the dry subsoil.

Now if a lot of farmers on the same soil measure the moisture in their subsoils next spring they will find to their surprise that they all have the same percentage; but some who have done good work, especially deep plowing, will have 3 or 4 or 5 feet while others will have only 2 or 3.

$5,000 Worth of Fruit Grown.

In the spring of 1894, I planted 2,000 young trees, apples, cherries and plums (which up to date have produced $5,000 worth of fruit) on the fallowed land which then contained 3 feet of moisture running about 17%. That year we had a few light showers and then about eight weeks' drouth. At the end of the eight weeks' drouth the subsoil in the middle of the row carried 16% of moisture right through, but adjacent to the tree roots it only carried about 12%, showing that the trees in the cube occupied by the roots had used up about 4%.

The mulch was dry; there was a crust under the mulch which also was dry; close up to the crust was soil carrying 16%, yet that moisture staid in place moving neither up nor down for eight weeks.

The fact that there was a crust under the mulch which was dry shows that the water was not moving up by any capillary action, since there is nothing with a much stronger capillary pull than a crust.

Soil Holds Per Cent of Water Against Upward Movement.

Every dry year we notice the same phenomenon, namely that 15 to 17% moisture will not move upward into dry ground by capillary action. This can be tested by anyone interested in the ground itself or in the laboratory by placing dry dirt or half dry dirt above soil containing about 16% moisture. Pressure makes little difference; the fact remains and always will remain, that active capillarity stops in our soils more or less at these percentages according to the density or capillary pull of the dirt tested. In the orchard tests, during eight weeks the moisture in the subsoil between the rows where there were no tree roots was reduced only by 1%, and this loss was caused entirely by evaporation through the interstitial spaces which, by the way, always goes on in a very slight degree owing to the slow movement of the saturated air, even when a good deep mulch is maintained. In the fall of the year when the days are hot and the nights cold this moisture becomes condensed in the mulch and especially on the roots of crops owing to the fact that on account of the sap circulating through the leaves in the cool night air the root is cooler than the soil. This underground dew can easily be seen as beads of moisture on sunflower roots any September morning after a cold night. Anyone who keeps track of his subsoil moisture will discover that after a light cold snow, or a cold night it may lose a small percentage or fraction thereof by distillation. The amount lost, however, in this manner, by thermal agencies has little effect on the status of the subsoil and, speaking broadly, we may say that water properly conserved in the dry farm subsoil stays there until the roots of some crop take it out.

Packing Seed Bed to Establish Capillarity.

Is there anything in the contention of some that by packing the seed bed we can establish capillary action with the subsoil?

I have never been able to discover any evidence of this.

In dry years we dig a hole in the subsoil when it is carrying its full quota of moisture, fill it up with dry or half dry dirt from the seed bed and tamp it solid, more solid than any packing could afford; after a month or so, the conditions are unchanged unless water is allowed to come in from the surface. The only thing noticeable under pressure is a very slight blending at the point of contact embracing four or five granules. This experiment can also be tried out in the laboratory in an even temperature by placing the dirt in jars or cylinders.

In a humid country where there is free water in the subsoil to support capillary action moisture may move up into the seed bed but never when there is a dry subsoil below to steal the surplus water.

Even in humid countries unless there is an excess of rainfall the subsoil can more than hold its own with the seed bed because being denser it possesses a superior capillary pull which, by the way, does not necessarily depend upon the density of the particles but on the density of the mass as a whole—the smallness of the interstitial spaces; and however much we may pack the seed bed we can never make it as solid as the subsoil which has never been plowed. For this reason when a tree is pot-holed and watered by hand it doesn't, as a rule, last long, for the solid ground around the hole steals the water.

What Capillary Action Exists On Dry Farm.

Now occurs the following question: Do we get any capillary action on the dry farm of any consequence?

We do—in the top 6 inches or so after wet weather before the water has had time to soak down into the dry subsoil below and become film water. This moisture coming to the surface for a few days is often mistaken for capillary water rising from the subsoil whereas it is nothing but the top inch robbing the second and third. We notice this action particularly after harrowing or packing. How can this moisture be practically utilized by the farmer?

When the seed rows are packed, without packing the whole surface; owing to the superior capillarity of the packed row, the water can be held there long enough for germination to take place even in the absence of further precipitation.

Must Depend Upon Subsoil Moisture.

The more we study dry farm physics the more we become convinced of the entire feasibility of raising crops on subsoil moisture, for speaking broadly, the moisture stays where it is put until the roots of the crops take it out and when we have 8 or 9 inches of water stored in 4 or 5 feet of good subsoil the odds in favor of making a crop are about 30 to 1; at least that is as close as I can figure it on a 30 years' average with an ordinary precipitation, and I can also say that although I have had three or four small crops in very dry years, I have never lost one by drouth.

The aim and object of this article is to demonstrate that if the farmer plows shallow expecting the moisture to rise into his seed bed he will be grievously disappointed; moreover, if the top inch of his subsoil underneath the plowed ground happens to become just a little too dry through insufficient covering, the roots will turn sidewise and spread out instead of going down and his crops may dry out even when he has saved up 4 or 5 feet of moisture in his subsoil.

CHAPTER VII

Dry Farm Fertilizing

IN order to understand anything about soil fertility we must first study the soil itself. Where did the soil come from, how did it originate? Geologists tell us that thousands of years ago, probably millions, there was nothing much on the earth but rocks and water.

The action of heat, cold, the washing of the waters, the erosion, the grinding of the glaciers and chemical action all helped to disintegrate the rocks—the result was soil.

Therefore the basis of the ground we raise crops on is fine particles of rock; mixed with these particles is usually a certain amount of organic matter, decayed or decaying roots, leaves, stalks, etc., in other words, vegetable matter which ultimately becomes humus.

The breaking up of soil granules, these particles of rock, is always going on by chemical action, by weathering, and by the friction and attrition of tillage.

When a farmer wants to make a solution of coffee for breakfast he grinds it up and the finer he grinds it the stronger the solution will be. The same with soil granules; no land can ever be absolutely exhausted for all time because the particles in which the mineral plant food is locked up are always being divided and subdivided by natural causes, as explained before, and this process goes on indefinitely, releasing more or less mineral plant food which is taken up by the water, thus forming the soil solution. This soil solution may be rich in a good soil containing one part of mineral matter in a thousand of water, or it may be poor in a depleted soil containing only one part of mineral matter in eight or ten thousand parts of water.

Available Plant Food the Point.

Now we come to the main point which is the gist of the whole matter.

It is not the mineral plant food which is locked up in the granules that makes a soil fertile or unfertile for the time being; it is the amount of available plant food, the free matter ready for the soil solution, which makes the difference between a good soil and a poor or used up one. Now comes the question: "Why does soil become exhausted by cropping?" Because the crops use up the available plant food more quickly than nature unlocks it.

Can we infer from this that if a soil is left alone, fallowed for a number of years, it will again become fertile?

If it is a perfect or complete soil containing all the necessary elements, it will; otherwise it may not, for if it happens to be short on some element which became easily available, and was more or less used up during the cropping period, and this element cannot be completely renewed by the unlocking process, then the soil solution must necessarily be deficient. Analyzing soil is a very long and arduous business and even when carefully performed seldom gives us a correct idea of what the soil needs. What we ought to do is to analyze the soil solution in order to discover how much available plant food we have in the soil and what it is composed of.

How Did Plants First Feed?

It is self-evident that when vegetation first commenced to grow on the earth it had to adapt itself in some way to the existing soil solutions or perish in the attempt, and it is an interesting question as to how this came about. Did the plants absorb the soil solution as it was, did they filter it, rejecting some of it, or did they take it in and then excrete the surplus portions of it by means of the roots? The bulk of evidence in this matter goes to show that they did, and do now, absorb the whole soil solution as they find it and that according to the solution so is the plant.

For instance, in a soil containing plenty of potash which forms a soluble salt with silica we always find large quantities of this mineral in the stalks of the grain; in a soil containing carbonate of lime in solution we find sometimes double the ordinary amount of lime in the alfalfa and so on, the crop being always a reflection of the soil solution.

When there is too much alkali, carbonates and sulphates of soda the plants absorb it and die. Too much soda in the soil will spot the leaves of trees, the trees get rid of it by dropping their leaves in the fall, and for this reason can stand a certain percentage better than some plants.

Filtration Theory.

To support the theory of filtration, another theory had to be invented—that of osmosis; but dry farming demonstrates that trees live and flourish in ground so dry that no osmosis between the roots and the soil solution is possible. Building on this filtration theory some of the older agriculturists formed the idea that one crop for instance would use up more potash than another, one more nitrogen or more phosphorus and so on, and that in order to even things up we should rotate the crops; but evidently this is not the true reason.

Now comes the Bureau of Soils and tells us that crops give out emanations from their roots which more or less poison the soil, and that much of the soil exhaustion and deterioration comes from this.

Dr. Cyril Hopkins scouts the idea, and as far as our dry farm soils are concerned, I am convinced the Doctor is right.

Dry farming with its dry farm soils and their chemistry and physics as I have always maintained is quite a different proposition to humid farming in the eastern states.

We can quite understand that the roots of crops at depth in wet soil may decompose with the assistance of the poisonous anaerobic bacteria, and give off emanations toxic to crops, the antidote of which is aeration.

Humus.

In my dry farming experience I have always found that the more roots left in the soil the more humus, the more humus the more crops. The hardest crops on the soil are those in which we remove the roots, such as beets, potatoes, etc. If we take the roots of any grain crop, dry them out, powder them up, make tea of them and apply it to some growing plant, instead of poison we find we have a fine fertilizer. Such evidence as the above leads me to believe with Professor Bolley that the true reason for crop rotation lies in the fact that the soil becomes crop sick when planted continuously to the same thing.

Crop Sick Soil.

What is crop sick? Anyone who has raised flax and potatoes has discovered what this is. Diseases are nothing but small organisms preying on big organisms. Germs, microbes, bacilli, bacteria, or whatever you like to call them have been found at the bottom of everything; there is some difficulty in discovering some because they are so small as to be invisible under a microscope which magnifies 3,000 times. All crops are more or less infested with them and the symptoms they produce are classed as different diseases or blights; but the point which concerns us is, that each genus of microbe has its own particular crop, and as long as this crop is raised to the exclusion of all others the soil becomes more and more infested with the diseases which belong to it, or as Professor Bolley remarks, the land becomes crop sick.

Improper Use of Fertilizers.

The Bureau of Soils gives as one of its reasons for believing in the toxic exudation theory that on some soils some fertilizers do more harm than good.

The answer to this is: They do in this country but not in others where fertilization is better understood. America is young; we are just beginning to feel the need of these things, in other countries they have been studying it for hundreds of years. In Germany the agricultural chemist does nothing but study out these questions, and we may be quite sure that no German farmer ever puts a pound of commercial fertilizer on his land unless he is assured of adequate returns.

The soil solution usually contains some form of iron, magnesia, lime, soda, silica, sulphur, and the compounds of nitrogen, phosphorus and potash.

These three last are the most soluble and disappear from the soil the quickest, and if we can replace these there is little trouble about the others.

Commercial Fertilizers Too Expensive.

The difficulty is there is no commercial fertilizer cheap enough to use which gives us the exact compounds of nitrogen and potash for instance as nature produces them in the soil. We can obtain the necessary phosphate from applying the ground rock in the natural condition which works perfectly; but for nitrogen the principal fertilizer is nitrate of soda, for potash kainit, and with both of these the utmost care is needed in the application. Strictly speaking, nitrate of soda is not a chemically correct nitrogen fertilizer such as we might consider nitrate of calcium, nitrate of potash or even ammonia to be, but the price, the cost of manufacture of these latter prohibits their use

Root Growth of Corn in Deep Seed Bed Such as May be Found on Deep-Tilled Land.

at present. Nitrate of soda which is brought from the deserts of Chili cannot be advantageously applied to all soils, especially those more or less alkaline, on account of the soda. Some of the nitrogen goes off in the form of ammonia which leaves soda, and under ordinary conditions this takes up carbonic acid and becomes carbonate of soda, a most undesirable alkali. The trouble is a little too much alkali, or even a little too much acid, may upset the chemical equilibrium of the soil solution. For example, when soil water, the soil solution, contains a certain percentage of carbonic acid, which it usually gets from humus, it can dissolve and hold in solution such minerals as protoxide of iron, lime, potash and magnesia, all necessary to plants. Now supposing enough soda attacks the solution to combine with all the carbonic acid by forming carbonate of soda; then it can no longer hold the former substances in the water and consequently its efficiency is reduced by that much. Kainit, also the great German potash fertilizer, contains other constituents besides the potash; it is described as a hydrous potassium magnesium chloro sulphate.

Commercial Fertilizers May Destroy Humus.

Now I would like to ask, does any farmer who is likely to try this in our country, does anyone in fact, understand what will be the exact action, combinations or affinities of these elements and compounds, when applied to the soil or mixed with other fertilizers under diverse thermal and moisture conditions? It has been proved in Europe, however, and I believe we may accept it as a fact, that the indiscriminate use of chemical fertilizers without adding humus (and I believe here is the principal trouble) leaves the soil in worse condition than it was before, which is not apparent however until the use of them is discontinued for some reason or other.

In the meantime it is impossible to deny that these same fertilizers when properly applied, are providing something for the plant, previously exhausted from the soil, or otherwise they could not restore the yield and the farmers would not buy them. It is absurd to imagine that a quarter of a million farmers in western Europe are buying kainit just for the fun of spreading it over their land. If we make a careful analysis of some soil, put it in a pot and place a plant in it, and after three years or so when the plant has ceased growing make another analysis and find a loss of nitrogen, phosphate and potash, would it not be a safe deduction to assume that the plant used them up?

If we analyze the plant and find them there, would it not be a still safer deduction?

If we place the missing compounds back in the pot and the plant takes another lease of life and grows equally well for another three years, would it not be as near to an absolute certainty as we can get? As I have often remarked, why not try some of these things instead of arguing?

Although mistakes in applying fertilizers may cause some in this country to search for other explanations than soil exhaustion, the repeated and almost universal using of these materials for the purpose of soil restoration in the older agricultural countries where the land has been worked for hundreds of years, demonstrates that if we know how, we cannot only put back what the crops take out but can continue to produce profitable yields for centuries.

Dry Farmer Doesn't Need It.

As far as the dry farmer is concerned he will need little or no commercial fertilizers probably for a generation provided he takes care of the humus.

This humus is what he must look to, for it is a fertilizer in more senses than one; it contains not only a fair amount of predigested mineral plant food, but provides a medium for the development of nitrogen, and last but not least evolves acids which assist materially in unlocking the fertility already in the soil granules. Therefore we consider that the vital point for the present is to conserve the humus. The future will probably take care of itself, for we have not only potash fields, but plenty of rock phosphate in the west awaiting development, and as far as nitrogen is concerned there are indications that we will soon be able to manufacture at a practical price all we can use from the atmosphere.

How to Conserve Humus.

The real problem then is, how can the dry farmer conserve the humus? To begin at the beginning, the very first thing to do is to plow the sod under deep which mixes it with a large amount of dirt, keeps it away from the atmosphere and allows all its gases and emanations to be absorbed by the soil. The next point to consider is that in taking a crop off the ground we should leave as much as possible of it to be plowed under.

Nothing could be worse than the method now in vogue of burning straw stacks, for when this is done the farmer is recklessly destroying somewhere about $15 worth of fertilizer to the acre per annum. The only correct method of handling this problem in the grain field is to head the wheat instead of binding it, leaving nearly all the straw to be plowed under.

How can humus be supplied to a field which needs it? There are two other ways besides manuring—plowing under green crops, and planting it to alfalfa. The best crop for this purpose is fall rye, because it can be planted in the fall and plowed under when a foot or eighteen inches high in the spring in plenty of time for planting corn or sorghum or other late crops. For fertilizing purposes it should be planted 40 or 50 pounds to the acre in the late summer in order to give it plenty of time to stool.

Plant Alfalfa Before Too Late.

Whenever a field shows signs of exhaustion, it should be planted to alfalfa before too late; I say too late because it is a difficult matter to obtain a good stand of alfalfa on poor soil. If it cannot be secured otherwise it will pay to plow under a green crop and enrich the ground before planting. The reason that alfalfa improves land in spite of heavy cropping (I am speaking only of dry land alfalfa) is that it leaves more humus in the soil than it takes out, or to speak correctly, than it used up in the soil which supports it. This humus is supplied by the 10 or 20% of leaves which drop off during the harvesting and also by the roots the weight of which runs into many tons per acre.

Sand bars and deserts reclaimed from the ocean or rivers may eventually become fertile as nature provides the humus; for plain ordinary sand may be rich in the essentials if the requisite compounds are provided to unlock them.

Humus the Essential.

At first the vegetation is sparse and far between but a little humus is getting into the soil; after many years the vegetation changes little at a time but becomes stronger and heavier and as it decays and goes back to earth again more and more humus is getting into the soil and eventually perhaps after hundreds of years the desert may become fit for the plow, especially if the winds assist in bringing soil from more favored localities.

Humus is of more value to the dry farmer than it is to his brother of the wet states on account of its water-holding capacity; it even surpasses clay in this respect, but unlike clay it improves the texture of the soil, making it more friable, for its particles being of organic origin it cannot combine readily with mineral matter to form a crust.

In summing up this case of fertilization, I would say that I believe that if the dry farmer rotates his crops, feeds them to cattle returning the excretions to the soil, plows deep, saves the sod at the start and takes care of the humus and soil generally, plowing under green crops when necessary, he will have little use for any further fertilization for a generation at least.

CHAPTER VIII

Packing and Fallowing

MY experience in this matter is, that the best yield from a crop is obtained not by having the field in best physical condition, the optimum state of density at planting; but just before maturing time.

It is self-evident that as the soil in a field after being plowed becomes more and more packed by every rain that comes and also by the weight of its own soil it gradually approaches its optimum condition for crops and then by becoming more and more solid it passes this point of perfection and becomes too solid.

This is an important matter to so adjust the best period of soil condition that it will meet the greatest need of crop growth.

When Best Condition is Needed.

Now the greatest need of crop growth is not when a crop is first planted, but when it is making grain; therefore, if by artificial packing we put our soil in the best physical condition as regards density at planting time when the crop does not require it, we lose by it, for when maturing time arrives a few months later, and optimum condition of the soil is needed to make the crop, we cannot obtain it, for it reached that point at planting time, several months ago, and the soil is now hard and solid just when it ought to be in the very pink of condition to support the crop in the making. Soils differ largely in respect to settling, and packing, and the following figures must be taken approximately.

When a field of our ordinary soil is plowed once a year 10 inches deep it will throw up a seed bed about 15 inches high, after this has been harrowed and disced and smoothed over it will measure about 14 inches.

Now we have seen that in plowing we have gained about 5 inches, divide the gain by 2, this gives us 2½ inches. This is the best condition for crops when the ground has settled or been packed down about 2½ inches, making the seed bed 12½ inches. This same rule applies to any depth of plowing, for instance, if we plow 8 inches and raise a seed bed 12 inches, the gain is 4 inches, divide 4 by 2 gives 2. Therefore a 12-inch seed bed is at its best when settled or packed down 2 inches, i. e., 10 inches deep.

Requirements of Different Crops.

There is also some difference in crops, the optimum for small grain calling for about one-half an inch more packing than other crops. In dry farming this best physical condition of the soil as regards its density is not so intense, so much packed as that in the eastern or humid states, because we have to allow a certain percentage for the accumulation of moisture which the eastern farmer need not bother his head about.

For instance, a greater density of the soil mass than the figures given above would be the optimum for root assimilation, if that were the only point to be considered; but it would not be nearly as favorable for the penetration of moisture, and since both are most important factors in production, we take the mean, the best all around for both reasons. Dry farmers who have been wrought up by reading packing literature sometimes wonder how it is that a field of small grain which gives magnificent promise at the start, all of a sudden when dry weather comes seems to stand still and begins to peter out.

Overpacked at Maturing Time.

The answer to this conundrum usually is, that by overpacking the soil was brought to its best physical condition at the start, and as it became more and more packed by rains, it became too solid, held the moisture too much on the surface, and when dry weather came the crop suffered. Vigorous growth at the start with short straw or stalks and a falling off at maturing time is nearly always a sign of too solid a seed bed.

Shallow plowing, a heavy flood and then dry weather are often responsible for this condition even in the absence of all artificial packing. In the same manner winter wheat when too much packed by the tramping of cattle is liable to be injured and its yield reduced. It should never be pastured excepting when the ground is frozen solid; there are exceptions, perhaps, but it is better to take no chances.

Little Artificial Packing Required.

The sum of my experience in this matter is that while some very light soils may be excepted; as a general rule, in our ordinary loams, little artificial packing is needed in dry farming; that land will reach its optimum condition at about the right time for maturing a crop, which is also the best time for yield, if allowed to lie fallow for a month or two after being thoroughly disced and harrowed. The fallow for winter wheat, of course, should never be packed.

No packing is needed for the corn and the sorghum field, for this can all be done with the disc and the harrow.

This cuts our packing down to compacting the land for immediate planting after plowing. This is something we never recommended, but if small grain is planted this way, the soil should be thoroughly compacted an inch or two, more or less, according to the rule given above, either by alternate discing and harrowing or by using a corrugated wheel packer.

For instance, if the ground is plowed 10 inches and the seed bed is 15 inches deep, the optimum is 12½ inches. This should be the depth of the seed bed in July; therefore, at planting time in May we reduce the seed bed an inch and a half or two inches, leaving an inch or so for nature to further pack the ground between May and July.

Sod is so elastic that no harm can be done to it by packing whenever it is expedient to do so to smooth the field.

When sod is plowed shallow, as Campbell advises, it has also to be packed or the horses will bring it home with them under the harrow.

Deep Plowed Sod Needs No Packing.

When sod is plowed deep (not to play with, but to raise a crop on) if it is thoroughly disced and harrowed alternately until fine enough to cultivate as it ought to be to obtain results, it will not need any further packing.

By packing the seed row, and not the whole surface, we give it the advantage for germination purposes, because being more compact, it will steal the surplus from the other whenever there is any free water moving, and by this means facilitate the establishment of the minute seedlings in times when precipitation is scarce.

Nearly all the seeding implements, by means of wheels or other devices, provide the necessary packing for this work.

Packing Will Not Cause Moisture to Rise.

The contention of Campbell and some others that by packing the seed bed, we can cause the moisture to rise from the subsoil is erroneous. In times of drouth the seed bed slowly dries out from the top down, even when the subsoil is carrying perhaps 10 feet of 17% moisture and not losing an ounce a day. We tested this out in the following dry years: 1893, 1894, 1908, 1910 and 1911, in the orchard, the summer-fallow and in fields planted to crops, by taking and weighing and keeping tab of the subsoil every few days. The farmer, however, will always obtain some kind of a crop when by deep plowing it is rooted in the subsoil.

Various Packing Implements.

We may call an implement a subsurface packer or an underground roller if we like, but if it moves on the surface, it packs from the surface down; because it also scrapes up a little dust on the surface, it need not throw dust in our eyes as to the work it does.

Nature packs from the bottom up, and this is the best kind of packing.

To fill up the air spaces between the furrow slices, the disc is the best machine because of its strong lateral pressure.

The disc is also safe to use on clay, packers and rollers are not. Some friends of ours in New Mexico lost some fine crops through not understanding this point; their soil was heavy clay loam and the moisture together with the packing made brick of it.

Professor Waldron at one of the Dry Farming Congresses gave us some interesting information on packing experiments, and in this connection I would like to say that I can always agree with a professor when he does practical work in the field. He told us, and I can report the same from my own experience, that the strips of land which were packed did not yield any more than those which were disced and in some cases the strips which were not packed with the packer yielded a trifle more.

Now if a man plows a piece of land and then harrows and packs, he will make a trifle better yield than if he only plowed and harrowed; but if he plows and harrows and discs, he will be a trifle ahead of the two former. The philosophy of this is: Every time you work the land, you add a little to the yield.

Mistakes in Summer-Fallowing.

I read an account once in some dry farm literature, as to how we should prepare the summer-fallow.

We were to plow it 5 or 6 inches, then harrow it, then pack it, then cultivate it every time a crust formed.

Some men manage to keep the wolf from the door by plowing 5 or 6 inches, but they don't get wealthy at it. This depth of plowing will hardly accommodate an inch and a half of rain, and if there is any moisture already in the soil, less than that. Then for fear it might take in more than its share of moisture, we are told to pack it. Now if the writer had a grain of sense, he surely would know enough (if packing were needed at all) to let the rain soak in first and then pack it some time afterwards.

To cultivate a fallow every time a crust forms is nonsense. When is the farmer to eat his meals?

Proper Fallowing.

It is very profitable to raise wheat by the fallow method; in the dry lands of California, Utah, Oregon and other states, people are becoming rich at it, and where land is cheap, it is almost as easy to have two wheat patches as one.

The land should be plowed at least 9 or 10 inches when the weeds are carpeting the soil about 6 inches high; here we get some humus.

It should be harrowed smooth and then disced and cross-disced without lapping, leaving it until another crop of weeds shows up.

This time it may be disced and cross-disced again, allowing the team to straddle the ridges made by the first discing so as to reverse the process.

The last of the weeds may then be cultivated out at wheat planting time in August or September and even if there are a few left, the frost will get them before they mature.

When water falls on more or less dry fallow land, it goes in until it stops. Now why does it stop? Because it requires a certain amount of water to support capillary action.

How Water is Stored in Subsoil.

Four or five days after a storm, when all capillarity has ceased, we dig down as far as dry dirt; if the precipitation has been 2 inches, we find about a foot of wet dirt above this dry dirt. This upper foot of damp dirt in ordinary wheat soil will be found carrying by test about 17% of its total weight in water. Presently another storm arrives and we get another 2 inches; the dry dirt takes it in again, and we get another foot; we leave it a week for capillarity to have full sway, and after it has stopped moving, we test it again; it still carries the same percentage, about 17.

Therefore we see that 17% is about all we can carry in ordinary soils; but we can save up perhaps 10 feet of it. What a chance for wheat and corn whose roots will go into this subsoil from 4 to 10 feet!

Testing Action of Soil Waters.

We have seen that dry dirt has no power to attract this moisture, for the dry dirt is below it, yet capillarity stops. If we dig out some of this dry dirt and put it above it, does it start up capillary action? No. Some argue that it does. Now instead of arguing why don't they try it? This is a most important point in dry farming and can be proved so easily, by obtaining a little dirt out of the subsoil, putting some dry dirt above it and some dry dirt below it, and watching results. A mason jar or an ordinary drinking glass can be used. The dirt, of course, must be taken from a subsoil which is dry below for this is the true condition of a dry farm subsoil.

On bottom land with water at 10 or 12 feet conditions are entirely different. The percentage which a soil will hold against capillarity and gravity varies with its quality. Some clays and humus soils hold as much as 20 and 25%.

On my ranch we have about 100 feet of dry subsoil under our fields, maybe more, but this is as deep as I have been, and anyone can understand that if the water were to fade away into this dry dirt by capillary action, it would be absolutely impossible to dry farm.

Out of this 17% moisture that we are able to hold, the crops can appropriate only about 10 parts, leaving 7 in the soil; therefore, if we can accumulate in the fallow about 5 feet of moisture we have in the neighborhood of 10 inches of water, and out of this 8 inches available for crops. This 5 feet of moist soil containing 8 inches of available water is sufficient to raise a crop.

How Water Escapes From Soil.

The only way it can get out of the subsoil is by air movement, evaporation through the interstitial spaces, and when this is checked by a seed bed 10 inches deep, the loss is a mere nothing. At the time of my experiments in water storage, I was building a shed, and while digging the holes for corner posts found 3 feet of moisture. I partitioned off a corner under this roofed-over, watertight shed and put a good mulch on it a foot deep; this subsoil was then carrying 17% water; at the end of three years it was carrying close on 15%, at 2 feet underground. There was no capillary action and the dry dirt was in the same position directly underneath it.

Some ten or fifteen years ago, when the public was beginning to open an eye as to dry farm possibilities, I was invited to read a paper. I advised the farmers to get their moisture first and then raise a crop on it. The agriculturists said that owing to capillary action this was impossible. Dr. Alway, of the University of Nebraska, however, thought different, (he makes his experiments in the field as well as in the laboratory). He placed some soil containing about 8 inches of water in boxes, mulched it and placed it under glass and grew wheat without a single drop of rain.

Get Water Into Subsoils.

All this goes to show that if you can accumulate 4 or 5 feet of moist earth in the summer-fallow you can raise a crop of wheat on it, whether it rains or not.

I feel like apologizing to the readers for harping so much on this capillary problem, but this is the one vital point upon which all dry farming hangs. The best preparation for the winter-fallow in a blizzard country is rough plowing.

While the ground is frozen there is no evaporation to speak of; but as soon as the ground commences to thaw in March a mulch should be put on, and even in winter this may be necessary if the weather stays warm and open, without any frost in the ground.

For raising large crops of wheat deep plowing in conjunction with fallowing is rapidly coming into vogue and will undoubtedly in many states be the method of the future.

We do not need to go to Canada to raise wheat, the only advantage they have over us is that the frost does their subsoiling for them; that is the reason they raise wheat. Give us a deep-tilling machine and a good man behind it and we can beat them at their own game.

CHAPTER IX

Roots and Subsoils

IN the old agriculture, the farmer concerns himself mainly about the seed bed, and the success of the crop is supposed to be determined by the degree of efficiency with which it is prepared.

In our new agriculture, it is most important that the quality and condition of the subsoil enter into all our calculations for it is quite a question which of the two bears the greatest relation to yield.

After we get over the idea that dry soil can rob wet soil of nearly all its moisture, we begin to get down to the actual facts in the case, which are: That we may have 100 feet of dry dirt underneath our subsoils (which hold our crop moisture) or a foot of dry soil above, but in spite of capillarity or gravity or anything else, this subsoil can hold a certain percentage of moisture quite adequate for raising crops which can escape only through the roots of said crops —or very, very slowly by an almost imperceptible evaporation.

It is this fact which makes dry farming possible, for if we were to depend on the crops catching a little moisture from each storm as it fell before it had time to fade away by capillarity into the dry subsoil, we would have a hard time indeed.

Instead of this, we find in practice that we can save up from 3 to 10 feet of moist soil almost any year we have a mind to, and that this moist dirt will carry a high enough percentage of water on which to raise crops.

Our ordinary clay loam subsoils will carry usually as high as 17 and sometimes 20%, sandy soils from 14 to 16 and some sage brush humus soils as high as

21 to 25%. Therefore the difference between a rich subsoil and a poor sandy one is this: The rich one will hold the same amount of water in a less number of feet. For instance, after say, 10 inches of rain have fallen, we find the clay loam has approximately 5 feet of 17% moisture, the sandy loam has 6 feet of 14% moisture, but they both contain about 10 inches of rainfall.

Now, which is the best for dry farming purposes? The one which holds the most water, for the roots can drink the more easily from an abundance, and have less distance to travel in order to get it.

For these reasons we perceived that the clay loam soils of the west with a clay subsoil are amongst the very best for dry farming. Campbell says: "Get the right amount of air and water into your soil."

Now many of western soils and subsoils are bulk for bulk near 50% air already; now what on earth do we want to get any more air into our soils for?

This may be good policy in the water-logged soils of the east and even in Lincoln, Nebraska, but in our dry western states I would say get all the water you can into the soil and let the air take care of itself.

Water and Air in Soils.

The philosophy of the whole matter is this: When water goes into the soil, it drives the air out; but when water dries out, the air goes in, and goes in to any depth, for we are living under an atmospheric pressure of about twelve pounds to the square inch. As I have already explained in a former article, our soils are never water-logged because all the free water is taken up by the dry subsoils almost as quickly as it falls.

Therefore, we may note that while the humid farmer has to worry about the air and lets the water take care of itself; the dry farmer worries about the water and lets the air take care of itself.

Showing Effect of Top Growth in Deep and Shallow Seed Beds. Seed in Each Box Sown at Same Date.

Relation of Water to Root Growth.

Now comes a rather pertinent question: How do the different percentages of water in the different subsoils affect the root growth of plants? They have a very marked effect not only on the roots themselves, but on the ultimate results, for if the subsoil does not contain the necessary amount of water, the roots do not go into it; cannot penetrate it, and the crop is more or less of a failure. A farmer would naturally suppose that the largest, sturdiest roots, such as corn roots for instance, would possess a better penetrating quality than such roots as those of wheat, rye, etc.

We find, however, that for some reason or other, rather the opposite is the case.

Unfortunately, I can give only the results of tests and experiments made on my own ranch, and soils, and cannot guarantee that these results would be absolutely the same on other soils and under other conditions; the difference, however, would be relative only, varying as the soil varies. I find that the roots of all crops will penetrate a subsoil easily and readily which contains its full quota of film moisture, from 14 to 17% or thereabouts. When the plowing is shallow, and the subsoil inadequately protected, evaporation may reduce this to 8 or 9 or 12%; then the trouble begins, for the roots instead of going down, spread out on the surface.

Some subsoils are harder than others and require more moisture to make them pervious.

There is also a difference in roots; those of rye will penetrate almost anything which is not less than 10 or 12% wet, wheat and barley 12 to 14%, and those of corn any ordinary subsoil not less than 13 or 15. Soft sandy subsoils are easy for the roots to enter even when these percentages are somewhat reduced. The roots of corn and especially sorghum seem to possess a greater facility for extracting a low percentage of moisture from the soil than those of small grain.

The roots of corn at the period of their greatest growth will often grow two inches a day and those of small grain will not be far behind.

Every cubic inch of soil a few inches below the surface will contain from three to four hair roots and these can extract about all the available moisture.

How Roots Absorb Water.

Here the question arises: How can the roots absorb moisture from soil granules with which they are not in actual contact?

As I have already shown, our soils will hold against active capillarity and gravity somewhere about 15 or 17% water. If we take some of this soil and place dry soil against it, above it or below it; the moisture does not move into the dry soil; there is nothing but a slight blending at the point of contact where the wet tapers off into the dry.

This sub-active capillarity at the point of contact if it amounts only to a quarter of an inch enables the root hairs to abstract moisture from say one-fourth of an inch on either side of them, making one-half an inch in all; therefore, when hunting for root hairs with a powerful magnifying glass, they will be found usually nearly every half inch or so.

We might ask: Why does this subactive capillarity stop where it does? Because there is not enough water to keep it going. The thinner the film on the granule, the tighter it is held and the harder to move. A granule in 17% land can take and hold a 17% film from free water; this is the limit of its power. Free water offers no opposition, but taking water from another granule is quite a different proposition. According to theory if a dry granule is placed against a wet granule, since they both have the same capillary pull, it will steal half its film, but in practice it does not do this, no doubt owing to the extra friction of dragging it off the other granule, therefore we find that a dry granule can take only half a film less about 10% more or less from a wet granule, and this, of course, brings the whole process to a dead stop inside of 10 or more granules. This action stops in soils when the moisture is reduced to somewhere about 6%. In root investigations we find, therefore, that where the hair roots are not too far apart they are able to assimilate nearly all the available moisture; but where they are far apart, such as the roots of trees for instance, we find after a long dry spell streaks of dry dirt where the root hairs absorbed the moisture, and wet or damp streaks where they were unable to reach it. In my dry farming orchard, after two months drouth in 1908, I found close to the tree where there were no hair roots at 2 feet underground, about 16% moisture, 5 feet from the tree 14%, 10 feet from the trees where most of the hair roots were, only about 11%.

We encounter many difficulties in film water investigations owing to the fact that there are no appliances to assist in this particular variety of research work. The granules can be examined and watched only under glass or else evaporation carries off the film; the glass makes trouble for the microscope, owing to refraction; besides which the reflectors are arranged for work with slides containing a section of the object to be examined, and are not rightly placed for throwing light on a growing root in a test tube. Some of these difficulties, however, can be overcome, but we have not the space at our command for a description of the method.

Roots can penetrate almost anything that contains the requisite amount of moisture; they are like very fine hairs and work their way through the interstitial spaces; then when they commence to grow and harden up, they crowd the soil granules and make room for themselves; thus we can understand that the root hair of a tree may find an inperceptible pore in a rock, eventually swell up, and perhaps split it all to pieces.

When the subsoil is not wet enough for the roots of crops to go into it, they spread over the surface of it like a fan; then if some very wet weather occurs, the tips may turn down and work their way in, but the root structure is poor and shows it in the crop.

Root Growth in Subsoils.

In a week or two from time of sprouting, the roots of most crops begin to reach the subsoil under the seed bed, then comes the question: Has the subsoil been put in condition by deep plowing to receive those roots?

On the answer to this question depends the crop.

The root system of crops and trees expands more quickly under dry farming methods than under irrigation or humid farming.

On my Colorado ranch, the roots of cherry trees planted 20 feet apart met in the row in seven years; those of apple trees 40 feet apart in twelve years. The roots of the cherry trees attained a depth of about 7 feet; those of the apples 10 to 15.

At first I was afraid to plant a commercial orchard; all the agriculturists I consulted said it would be impossible to hold enough water for crops above a dry subsoil hundreds of feet deep, that capillarity would take it all down into the dry ground until there was nothing available left.

In order to try this out, I planted a dozen trees in 1886, and kept them well cultivated; at the end of 1890 I had 10 feet of moisture saved up in the subsoil. I naturally began to study the moisture question and discovered that active capillarity stopped in my best soil at about 17%. This was all I needed; anything can be raised on 17% soil and I planted a commercial orchard in 1894 after securing 3 feet of moisture by fallowing. The profits to date have been about five thousand dollars for fruit, less about one thousand for trees and expenses. In planting trees, a question often asked is, if it would pay to dynamite the ground. I do not know; but what I do know is that the roots of trees will go through almost anything but solid rock if the moisture conditions are right.

Absorption of Moisture and Rising of Sap.

The manner of the absorption of moisture by the roots and the rising of the sap have never been satisfactorily settled by plant physiologists, and now dry farming is beginning to shed some light on this subject.

The old idea from humid countries was as usual a conception born of an abundance of water; that the roots absorbed the soil solution by means of osmotic currents. In dry farming, farming on film water, we believe there are no osmotic currents; that film water cannot support osmosis!

When a root hair engages a granule, the moisture passes into it without any visible return current. It is quite possible, however, that osmosis may act where there is plenty of water, although it seems certain that the roots of dry farm crops do not in any way depend upon it.

The theory of osmosis fitted in admirably with the root pressure theory which is to this effect, that absorption of the soil solution by osmosis created a pressure which caused the sap to rise and that this continued absorption caused more pressure and more sap to rise and so on.

It has been only in the last decade that scientists have awakened to the fact that a tree will grow for weeks without any root; that a cottonwood, for instance, may be cut down in April, and it will leaf out and not die perhaps until June or July; that cuttings will live and put forth leaves without any root and that in the tropics there are some air plants (in which the sap rises) which never have roots.

Some well known French scientists of Paris decided to sift this matter further. They discovered first that there actually was considerable pressure in the sap cells of a tree; they also found out that when the sap was rising, the protoplasm in the cells was expanding and contracting, we might say sucking or pumping, that when it was rising fast, the pumping was rapid and vice versa; that when through hard frost or some other injury to the tree, the protoplasm in the cells was destroyed, the sap ceased to rise in those cells. This convinced them that the protoplasm had everything to do with the rising of the sap and finally microscopic investigation showed the expansion and contraction of the protoplasm under the stimulus of heat and light.

This theory is also in line with everything else in nature for everything organic and living is built up of protoplasmic cells, from the smallest bacillus which is composed of one or two, to man who is composed of billions.

All plants, all cellulose, all wood is built up of these cells, every part of the tree or plant.

The amoeba, one of the lowest microscopic forms of animal life, is nothing but one or two of these same cells of protoplasmic jelly which floats about in water and obtains its nourishment by sucking it in and squeezing it out again. This is just what the cell in the tree is supposed to do.

Effect of Heat.

Biology teaches that every thing that has life can convert heat into energy. This seems to be the case in the vegetable world; the trees and plants are more or less dormant in winter, but as the heat of the sun increases in spring the vegetation warms up, the protoplasm begins to work, the sap rises.

Have we any other evidence that the heat does the work? Yes, the heat is used up or rather rendered latent in the tree by the work it does, and if we reverse the process we can get all the heat back again.

To reduce a tree or any other vegetable matter to its original elements we dry it and set fire to it. The result is we get so much ashes, so much gas and smoke, and so much heat. We have already seen how the heat was acquired; the ashes are the mineral elements out of the ground and the gases go back to the atmosphere whence they were taken by the leaves.

If we burn 100 pounds of dry vegetable matter we get less than ten pounds of ashes, which means that less than one-tenth of a plant or tree comes out of the soil. The other nine-tenths which are mainly carbon, oxygen and hydrogen are derived from the water and atmosphere.

The main constituent in the composition of vegetable matter is carbon acquired by the leaves from the carbonic acid gas (carbon dioxide) of the atmosphere. The mineral elements are usually less than one-tenth although in some soils where there is plenty of lime or silica they often approach this amount. Supposing, however, they are one-tenth of the total dry weight, how strong would the soil solution have to be to deliver this amount of mineral matter to the plant?

Strength of Soil Solution Necessary.

This has often been worked out in theory by scientists, but Professor Atkinson in the number of this magazine of December 15th, tells us how it was practically tested out by Professor Thom with growing plants. According to these experiments it requires in ordinary soil somewhere about 400 pounds of water to make a pound of dry vegetable matter; we have already seen that only about one-tenth of this pound comes out of the soil, so that all this 400 pounds of water will have to carry will be one-tenth of one pound of mineral matter. A tenth of one pound in 400 is only 1 in 4,000. Therefore a good ordinary soil solution may carry only 1 part of solid matter in 4,000 of water. The soil solution is not mud, it is not fine soil, it is not even soup or muddy water; it is clear water fit to drink; in fact, some waters used for drinking purposes are pretty strong soil solutions.

Dana says that all water out of the ground contains more or less of the following minerals necessary to plant life: Iron, potash, phosphorus, soda, lime, sulphur, silica, magnesia, chlorine, etc., but these would not be found, of course, in rain or distilled water.

As Professor Atkinson remarks, the richer the soil the richer the soil solution, and the richer the solution the less water required to make the crop.

Humus is a tremendous factor in providing a rich soil solution not only on account of the predigested mineral elements it contains, but on account of the acids evolved, which render different elements of the soil soluble in water.

Some hold the opinion that roots are able to strain the soil solution, accepting some elements, rejecting others. There is little evidence of this. In a soil rich in potash, and the soil solution full of silica, we notice it (the silica) in all the crops, the same with lime, with everything, and when the solution is too alkaline the soda goes into the plants and kills them. The probability is that since solutions existed before the plants, the plants had to adapt themselves to them, or perish in the attempt.

CHAPTER X

The First Year on a Dry Farm

DRY farming is done mostly on moisture already conserved in the soil. Nature does not do this for us, we have to do it for ourselves; therefore, although I might draw up a lovely program for the new settler whereby he might raise everything desirable for himself and family and the stock, it would be just so much waste paper if the weather happened to be dry the first year and no moisture already in the ground. This is a condition any new settler may be called upon to face and he should be prepared for it. When a dry farmer understands his business there is nothing to worry about in a dry year any more than there is for the business man when times are dull, but his first year is a different matter, and if he should happen to find it a dry one, which may come to pass once in every ten years or so, he cannot raise very much; but he can use his time to such advantage, that he can get his money back and more too, the next year.

What to Do First.

The thing to do is to plow and break sod, and not to quit or give up simply because the ground is dry. Let it be thoroughly understood that there is no harm whatever in dry plowing, provided it is not planted until thoroughly soaked up and settled. The tilth of the soil at the time of plowing matters nothing; but at time of planting it matters everything, and the roughest kind of land can be put in shape after the snows of winter and the rains of spring.

For this work we need horse power and there is no sense in starting to dry farm with ponies. If a walking plow is used, three horses weighing at least

1300 apiece are needed; the Spalding is the only riding plow fit for dry farm purposes, it does beautiful work and requires four horses at least. The new settler will find himself surrounded by neighbors, some of whom live from hand to mouth by skimming the surface; but let him beware of their advice, for his whole future and that of his family may depend on the work he does this first year.

Shallow Plowing Courts Failure.

It is true that in a good year, like last for instance, the surface farmer may raise even thirty bushels to the acre, but every cent he makes will go like water as soon as a dry year comes; whereas the deep plowers can make forty to fifty bushels in good years and close to thirty in dry years. If everybody plowed deep, 8 inches for sod and at least 10 for old land, there would be no dry years. After the first year the deep plower always has moisture, he has money in his pocket, he doesn't worry when the dry weather comes, he mulches his crops and goes fishing.

If the farmer goes on his new place in the fall of the year, and there is considerable moisture underneath the sod, it would be safe to plant winter wheat if he can get it in by September; but if the ground is medium dry it would be much better to plant rye which is the safer crop of the two, and can be planted any time up to the holidays and used as grain or cut for early hay the following June.

Plowing can be continued sometimes more or less all winter; a friend of mine near Denver was plowing this winter with 2 inches of frost in the ground, using a Spalding.

Corn and Sorghum Best for First Crop.

If the new settler goes on his place in the spring, he had better confine himself to such crops as corn and sorghum.

To attempt to raise small grain on newly plowed sod land which has not been fallowed, is taking desperate chances, but if he should determine to take such a chance, then I would advise him to plant hard Russian wheat. The earlier the ground is plowed the better the chance for a crop.

Corn land even plowed in March will yield more heavily than the same land plowed in May. After a wet snow before the frost is all out the farmer can often cut the upper two inches of the sod with the disc thus making the plowing not only easier but quicker, when all the frost is out and the land ready for the plow.

Reasons for Deep Breaking.

In breaking sod 8 or 9 inches the idea is to make a good deep seed bed, raise a good crop at the start, and also convert the grass and roots into humus by burying them where the atmosphere cannot steal the gases; which will keep the field fertile for years.

To advise the plowing of sod 2 or 3 inches, taking off the very cream of the soil, leaving it in the sun to be burned up and dissipated into the atmosphere is a crime against agriculture and an outrage to our intelligence.

It takes work, but it pays in the end to thoroughly fine the surface of the new breaking before seeding; my rule has always been: Work it enough so that it can be cultivated.

The easiest way to do this is to have one team plowing, and another discing and harrowing alternately, catching it fresh from the plow; but if the farmer has only one team, then I would advise plowing two hours, then discing and harrowing two hours. On a hot day, sod will commence to bake in a couple of hours; it should be worked up as quickly as plowed.

No Packing Necessary.

If this is properly done no packing is needed, but if the farmer wishes to flatten out the sod with a roller there is no harm in it for sod is so elastic that it is almost impossible to injure it by packing unless it contains a heavy percentage of clay. When the sod is disced before plowing and then disced again on the other side after plowing it can be readily understood that it is pretty well cut to pieces. It was all very well to plow sod shallow and sit on the fence and wait for it to rot in grandfather's time, but this is not an attitude worthy of the 20th century farmer with 20th century implements. Flax is a good crop to plant on the new break and if the weather is favorable a good crop may be secured the first year. It is often said that flax will grow on shallow plowing; the truth is, it will stand poor plowing better than some other things; but like everything else, the ordinary yields can be doubled by good work.

Potatoes sometimes do better on sod than on anything else, but will grow only on certain soils, and no one yet has ever been able to determine what constitutes a potato soil; therefore the only way is to try it, or find out from the neighbors.

Plant Alfalfa As Early As Possible.

If the new settler has started his farm in time to do some fall plowing he should certainly plant some alfalfa in the spring. The whole thing in getting a stand of alfalfa is to plow deep, and a few acres should be planted if only for an experiment either in rows or broadcasted or drilled.

By planting a few acres every year the farmer soon has an abundance of feed, and while he is waiting for the alfalfa, fall rye will be found the best thing for hay where quantity is desired.

Winter Wheat the Money Crop.

In the spring or early summer when the crops which he has decided to plant are all in, what can he turn his hand to next? Now is the time to plow and prepare for winter wheat. This is the great grain crop for the farmer who wishes to raise something for market.

If the ground is properly prepared by deep plowing as recommended above, there is no reason that land put into this grain cannot pay for itself, the first crop.

After the plowing there is nothing much to do but keep the weeds out until planting time in August or September. The best way to do this and at the same time catch all the moisture that comes, is to disc and cross disc without lapping. This ridges the land in small squares and will hold any cloudburst that comes unless there is considerable slope.

When planting time comes the very best wheat to plant is Turkey Red, the finest selected seed. I have tried many varieties; some freeze out or tramp out when the cattle are on, some are not vigorous and inclined to rust, and some in mild winters and wet springs will outyield it, but on a general average it beat any other variety we can plant in general hardiness, drouth resistance and yield.

For market purposes spring wheat should never be planted on the dry farm in a climate where winter wheat can be grown.

Trees On New Land.

A question often asked by the new-comer is: "Can I plant trees or alfalfa on newly broken sod?" Yes, both. The trouble with trees is allowing the sod to get into the hole and make air spaces around the roots; this will burn out anything. To avoid this trouble is very easy. Plow so as to leave a dead furrow where the row of trees is to be planted; then take the plow and work up and down this dead furrow until all the loose sod is banked up on either side and dig the holes in the straight dirt using what you throw out to cover the roots when planting.

As far as alfalfa is concerned, planting it on sod got a black eye from the surface farmers, for nothing on earth can be expected to do its best on new land plowed 3 inches. Alfalfa will do much better on sod than on old land if the soil is light and the seed bed prepared as we recommend. On heavy soil it will do well either on sod or old land. I rather prefer the new break myself when properly plowed 8 or 9 inches and well fined down.

Implements Needed.

As regards implements on the dry farm besides the plow, a good steel lever harrow and a reversible disc are needed to prepare the seed bed; an ordinary corn cultivator with three blades in each row, six in all, is good for all row crops; and for late cultivating of wheat there is nothing like the spring tooth weeder.

As far as the packer is concerned, I find that land plowed a month or two before planting, any fallowed land in fact, is better without it. When land is plowed for immediate planting an extra discing and a harrowing equals the effect of packing and yields about one-half a bushel more per acre.

Some assert that it is easier to reduce sod by first packing it before tearing it up with the disc and harrow, others never use a roller or packer of any kind; but if such an implement is needed the combined clod crusher and packer is obviously the best; this is made in the usual model, but with the wheels rough and corrugated at the edges.

Dry Farming Profitable.

Dry farming is a very profitable variety of agriculture at present because if the farmer follows the deep plowing system he can produce crops much cheaper than the irrigator and yet obtain irrigation prices, and it will be a great many years before the 3- to 6-inch plowers abandon their present methods and begin to flood the market with crops which will eventually reduce prices. The surface system of western farming which means raising crops by intensive cultivation instead of deep plowing means long hours, hard work and small crops.

It takes very little more time and work to plow 10 inches than it does 6, it means simply one more horse to the plow, and the subsequent cultivation necessary is seldom more than to keep the weeds out.

Why Farms Were Abandoned.

Hundreds of settlers in eastern Colorado abandoned their farms in 1892 to 1894 because they started in plowing their sod 2 to 3 inches in 1893; then '94 was dry, the top of their subsoil was dry because there was not enough plowed sod to mulch it; they could not get the plow point in, and the plow down; there was no chance to make a seed bed and little or nothing was raised.

There was another side to this picture, however. Some came from the New England states and plowed 8 or 9 inches; a few came from Germany and Sweden; they plowed deep because they knew no other way; every one of these staid; they are rich men today.

For the guidance of the new settler, I offer the following rules which I have found by nearly forty years' experience to be of value in making money at dry farming:

Rules to Follow.

Keep all land mulched as far as possible winter and summer, the exception being that land plowed in the fall for spring planting is best left in the rough state until the frost is out when evaporation starts; then, however, it should be harrowed over.

To catch run-off all crops should be cultivated across the slope rather than up and down with the slope. Fallowed land should never be packed. Fallow land for a few months before planting; a few weeks are better than nothing. When raising small grain plow in the spring for fall crops and in the fall for spring crops. When there is no moisture in the land for winter wheat, plant rye which is just as profitable. In planting alfalfa pack very lightly in the seed rows and not at all the rest of the surface. When planting shade or orchard trees set out a whole row and keep them cultivated.

When there is a good mulch on your corn in dry weather it does more harm than good to keep on cultivating.

Plowing dry in the fall is better than no plowing, for such land nearly always becomes soaked and settled with the winter and spring precipitation, when it can be fined down with a little discing and harrowing.

Never list corn in the hard ground without previous plowing.

Always provide a deep seed bed for alfalfa and never plant anything with it.

Never disc in a crop on the stubble, the only exception being rye for hay.

Try to mulch every crop at the critical period, which is when the spring rains have stopped and the summer rains have not begun.

Plant largely of the surest crops, such as corn, sorghum, rye, winter wheat and flax.

Get your feed first and then buy the cattle to eat it. Plow deeper if you can, but make the minimum for sod 8 inches, for old land 10, provided, of course, that you have the soil.

High Altitude Corn on Land Plowed 12 inches Deep on Farm of E. R. Parsons, Colorado—6,000 Feet.

CHAPTER XI

Keeping Track of Moisture

OUR previous articles on soil moisture aroused so much interest in this matter and we received so many pertinent questions that the time seems opportune to present to the farmers a way for determining themselves the action of moisture in their more or less dry soils as opposed to the action of water in the wet soils of the humid states which so far are the only soil and water physics in print, and which are taught by many agriculturists without regard to local conditions.

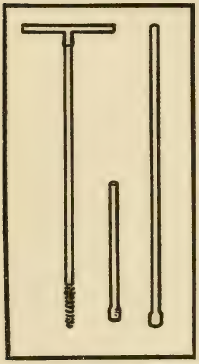
With a few simple implements, some of which he can make himself, the farmer can tell, by a few minutes' work every day, exactly what moisture there is in any particular field, how much any crops left in the field when taken off, whether there is enough to justify planting another crop without any further fallowing, whether the moisture is coming up or down, what kind of soil culture accumulates most moisture, and what kind conserves it the best.

Determine Amount of Moisture.

If he wishes to go further than this and is pretty good at figures he can, by comparing his moisture notes of vacant blocks of soil with those of blocks occupied by crops, determine for himself what amount of moisture any tree or crop is using up or has used up during the growing season. When a man takes his soil auger and finds that he has two or three feet of moist subsoil under his 10-inch plowing and only one under his 3- or 4-inch, he has an object lesson on his own place which impresses him more than any institute talk.

The Soil Auger.

This soil auger is the most important implement of all, and every farmer should have one. To make one, the first thing to get is a common 2-inch wood auger, such as any carpenter uses; the blacksmith must then weld it onto a piece of common iron gas-pipe about 4 feet long, with the ordinary thread for screwing onto another piece at the end. A two-way right-angled joint, a T in fact, is used for the handle, and by taking this off at any time more pipe can be screwed on, and the length increased as much as desired. This implement is of as much value to the man about to buy a ranch as it is to the man on his own farm, for if he takes his auger along he can sample the soil just as a grocer does cheese, and by bringing up dirt in the flanges of the auger can tell what kind of soil or subsoil he is thinking of purchasing.



Soil Auger Used in Testing Soils and Subsoils.

If every buyer were to do this instead of "going it blind," we would not hear of so many cases in which men have bought ranches and when they came to plow, finding out they had no soil.

Method of Testing for Moisture.

The method of testing soil for moisture is very simple. We take the auger, bore a hole as deep as we want it, then bring up a chunk of dirt sticking to the auger like a cork on a corkscrew, this we take home and weigh it, keeping say just 10 ounces of it; we take this 10 ounces of dirt and place it in an oven until all the moisture is baked out of it without burning it, which would take out the humus.

We then weigh it again and it weighs only 9 ounces, 1 ounce has gone; what was that ounce?

Water. In speaking of soil we usually use the words per cent or percentage to denote proportion in a hundred parts; therefore according to our test, if in ten parts of damp soil we found one of water we would find ten in a hundred, and we would call that soil 10% wet, or soil carrying 10% of moisture.

The percentage method is the easiest way to calculate moisture because supposing, for instance, we wish to discover how much moisture is contained in a given block or cube of dirt; all we have to do is to take the percentage as above described, say one test for each foot and then figure out the average percentage for the whole block; we then reduce the result to inches and know just how much we have in the field or in any particular cube of dirt.

The percentage differs as the weight of the soil varies, sandy soils, for instance, weighing heavier than clay soils, but an approximate estimate in every-day average soil would be about 2 inches of water to every foot of dirt carrying 10% moisture, therefore, if the soil carried only 5%, a foot of dirt would carry only 1 inch, and so on.

This refers to average soil weighing, when dry, about 90 pounds to the cubic foot. Sandy soil will often go 110 pounds to the cubic foot, and some clays are as light as 75 pounds; a good average for ordinary loams is about 90 pounds; these are, of course, dry soil weights.

Application to Practical Work.

The next part of our program is to consider the practical application of these moisture studies to the work of the every-day farmer. We will suppose that this gentleman has been raising a large crop of corn, which has just been hauled off the field, and shocked in the corral; he takes his auger, makes one or two borings in different parts of the field, tests the dirt and finds he has left in the field 4 feet of moist dirt carrying on an average 7½% of moisture; can he risk planting winter wheat on that, or can he not?

Seven and one-half per cent means about 1½ inches to the foot; therefore, he has in the 4 feet only about 6 inches of water; but here is a most important point to be remembered, that the last 5% of moisture in the ground is unavailable, for when the water becomes that scarce in the ground the roots of plants are unable to extract it; therefore, we may as well subtract that 5%, which leaves him only 2 inches available water in 4 feet of moist soil. If the farmer is a cautious man, and the fall is fine and dry, he will plant no wheat with this amount of moisture, but perhaps take a chance on rye.

He will then go over to his fallow land, which was plowed 10 or 12 inches deep in May, he screws in the auger, up comes a lump of wet dirt which will ball in the hand, he has 5 feet of 15% dirt. Ah! he thinks this is something like he figures it out; after deducting the unavailable 5% he has 10% left, 2 inches of water to each foot of dirt—10 inches in the 5 feet—the wheat goes in.

Determining Amount of Water Used by Crops.

In order to acquire an approximate idea of what a crop is using up, these same experiments must be made in the soil in which the crop is planted, and in some soil of the same variety in which nothing is planted; but all other conditions must correspond.

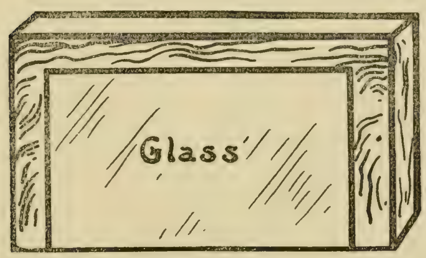
A patch of oats is planted, a small corner of the same field is left fallow; it all contained the same amount of moisture at the start; but when the oats have ripened and been harvested, we find with the help of the soil auger, that for as many feet as there is any moisture, the ground contains only 4 inches; while in the corner which was not planted we find 14 inches; now it is easy to figure from this that the crop used at least 10 inches in the making; for the precipitation was the same on both, the evaporation about the same (excepting a trifling amount saved by the shade of the oats) and all other conditions approximately the same. Apropos of this matter I might remark that in average weather, not too hot, it is my experience on 8 inches; I mean by that, 8 inches of water conserved in the ground.

The same test may be applied to trees. In making tests in the orchard in dry weather or in fallow land we often go through a dry crust into 17% moist soil, and yet, as long as there is a good mulch, this moisture does not waste, to any extent, by evaporation, neither does it move by capillarity into the dry crust above or into the dry subsoil 5 or 6 feet below.

Finding How Capillarity Works.

To observe the action of capillarity or root growth in the soil, there is nothing better than a wooden box about 18 inches or 2 feet deep, of which one side is glass. An aperture can be cut in the side of almost any box and a piece of glass, slightly larger than the aperture, inserted on the inside; the dirt will hold it in place.

We are told by some agriculturists that there is no reason to plow deep because the moisture is always coming up out of the subsoil to the roots of the crops in the seed bed by capillary action, and Campbell says pack the seed bed to create capillary action between the subsoil and the seed bed. Some farmers who have never tried this out write that they are afraid to plow under manure or litter for fear of impeding



Glass Front Box by Means of Which Moisture Movements and Root Growth May Be Easily Studied.

this action. Although nearly everyone believes it, the whole thing is a delusion and cannot possibly happen unless free water is present in the subsoil. In a former article I have already given the scientific reasons for this, but seeing is usually believing; so let us try it out in the box so that we can base our farming on facts as we find them. This action is supposed to take place in dry weather, the water from the subsoil reinforcing the moisture in the seed bed.

Testing for Practical Capillary Movements.

Therefore, in order to test this out; as soon as dry weather commences we dig down about 2 feet into the subsoil and half fill the box with the dirt; if the soil was much loosened in the process, it should be tamped as solid as it was in the field. We then fill the upper half of the box with dry dirt, or nearly dry dirt, and watch results through the glass. The moisture line is easy to see, the dry dirt is light in color, the damp dirt dark.

The box should be placed in a cool room and the line watched every day.

Does it move up? Does it spread up and out in the dirt above until all of it is one color? Unfortunately for the old theories it will not do this unless there is plenty of free water somewhere down below; a condition rarely found on the dry farm.

Someone says pack it and it will move. Take a board and place it on top of the dirt inside the box and pile 100 pounds of rocks on it, then try 500—does it rise?

Is there any way we can make it rise? Only by supplying free water, which is never found in a true dry farm subsoil excepting for a few days after a storm before it has had time to soak down and become film water. Farms on river bottoms and over water at 9 or 10 feet cannot be considered dry farms. There are many places along the Missouri, Yellowstone, Musselshell and other rivers where the water is found a few feet from the surface and the farms are virtually sub-irrigated; such lands are invaluable for alfalfa.

Amount of Water Carried by Subsoil.

A true dry farm subsoil after drainage (action of capillarity and gravity) has ceased usually carries about 15% to 17% of water; if it carries much more than this, then there is free water in the interstitial spaces and drainage has not yet ceased; but it seldom lasts for more than a few days after precipitation. In making these experiments there is no need to trust entirely to sight; samples may be tested from any part of the box by the method previously explained. Then it is thoroughly understood by our farmers that in dry weather there is no chance of getting the moisture up to the crops, they will see the necessity of plowing deep in order to get the crops down to the moisture.

Free water, or rather water over and above what each granule can retain as a film, is always found in the top 3 or 4 inches for several days after wet weather, and after harrowing we find it next morning coming to the surface; this, however, is not from the subsoil—it is simply the top inch robbing the second and third. When the soil contains free water it will wet the hand or anything in close contact with it; if it will not do this, it is safe to estimate the percentage at less than 20.

How Far Will Water Go in Dry Soil.

To discover how far water will go in dry earth, it can be introduced into the box through a tube or poured on the surface. When water is introduced into the center of the dry dirt near the glass the farmer will be surprised to see how little of it rises by capillarity, even with plenty of free water the upward pull of capillarity in soil is not equal to the combined downward pull of capillarity and gravity (weight).

After a day or so when all capillarity has ceased in the box and the free water drained off; if the farmer takes some of the wet dirt and tests it he will find it holds somewhere from 14 to 17%, according to his soil, and this will be the percentage his subsoil will hold against any force or agency but evaporation. However well a field is mulched there is always a slight evaporation on account of the air between the granules; but under 10-inch plowing evaporation may not amount to one-fourth of 1% a month; but under shallow plowing it may amount to 2 or 3%. Therefore, in fallowed land with deep plowing and a fair amount of cultivation, we may say that water stays where it is put, until the crops use it up, and transpire it back again into the atmosphere; otherwise it would be impossible to dry farm. The box with the glass window may be used also for observing roots; corn or small grain may be planted close to the glass and the roots after a while will show through; even germination may be investigated and corn tested by planting the seeds under the dirt right against the glass.

Dr. Alway, of the University of Nebraska, who teaches physics, mostly from experiments in the field, tried these matters out pretty thoroughly when he planted wheat and other plants in damp dirt in cylinders; he tells us the roots went down 6 feet to moisture instead of the moisture coming up to the roots, and the plants grew and produced seed or grain under a roof where no rain could reach them, and the temperature up to 100 and 124°.

Prevailing Opinion on Capillarity Wrong.

Dr. Alway supports my contention that the prevailing opinion about capillarity expressed by Campbell and others is wrong, in these words: "The prevailing opinion as to the extent to which water is lost from dry land subsoils by evaporation following upward capillarity movement appears to be without experimental foundation." Nothing could be clearer than this.

Over Aeration.

Manure or straw or cornstalks can be plowed under without cutting off capillarity which doesn't exist; but not too much in one place on account of over aeration which burns the crops. Ten loads of manure to the acre can hurt nothing, and the best way to apply it is to disc it in on the surface in the fall and plow the whole thing under, 10 inches deep in the spring. A field which has been regularly manured and contains a goodly amount of humus will hold 20% of moisture against drainage, while the same soil without the manuring may not hold more than 15%.

CHAPTER XII

Dry Farming for Profit

DRY farming in any locality where the soil is good and deep and the precipitation 15 inches or over should be very profitable work; but if we take a trip through any of the dry states and visit at many of the farms the conclusion seems to be forced upon us that many of the dry farmers are farming for fun, not for profit.

One year not very long ago I was visiting with Dr. Cook up at Cheyenne, and inspecting his fine crops raised on 9-inch plowing and only 3 inches of precipitation during the growing season; but with the help of several inches conserved by plowing in the fall. While there I visited a ranch about twenty miles from the city and a most astonishing sight met my gaze. I beheld about 100 acres of oats, every one about 5 or 6 inches high and the whole field headed out and more or less green.

When the owner came along I said to him, "How on earth did you get such a peculiar looking field of oats?"

"Isn't it a freak?" he said. "You know I don't know very much about dry farming, and I read in some literature to plow sod only about 2 or 3 inches, which, not having heavy horses, suited me down to the ground. After plowing I flattened out the sod with a roller, ran a slanted harrow over it and put in the oats."

Dwarfed by Shallow Plowing.

"Well," I said, "as an exhibit of plant dwarfing, which they do so much of in Japan, it is one of the most wonderful sights I have ever beheld."

We then sent for a spade, and started to examine the oats; we found that the sod was simply a mass of roots like those of a plant in a flower pot, and when we pulled up the oats the sod came with them.

We could not find a root anywhere which had penetrated the soil underneath, and, of course, this explained the mystery; the oats were root-bound in 2 inches of sod.

The trouble had been that the 2-inch covering was not enough to hold the moisture in the subsoil and its surface below the sod being dry the roots could not possibly get into it, but the crop acquiring a little moisture from passing showers was able to keep alive and make a stunted growth.

This man got nothing but a little grazing off his field, while another farmer in the same county who had broken his sod 8 inches in the previous fall raised 45 bushels of oats to the acre.

The Usual Method Followed.

This man of the stunted oats intended to backset his field the next year and waste some more seed trying to farm on the other side of that 2-inch sod. I eventually persuaded him to plow under the whole thing 8 or 9 inches deep that same fall and put it into Turkey Red. He rented two extra horses, which cost him $50, and next year took off 33 bushels of hard wheat per acre. This is the difference between farming for fun and farming for profit. I must admit, however, that it is a little harder work, as well as better work, doing a good job of plowing, than it is to sit on a sulky and plow 2 inches and then backset it and play shuttlecock with the pieces of sod until they wear out.

Deep Plowing Saves Labor in Packing.

There is a class of farmers which never get beyond 6-inch plowing; but they work night and day with packers, cultivators and discs; they put as much work into 50 acres as will do very well for 100 properly maneuvered. They raise, once in a while perhaps, 20 or even 30 bushels per acre in a wet year, but in average more or less dry seasons only about 10, and their regular average for ten years or so would not be 15. The labor expense on a crop of grain runs over 10 bushels, or rather the price thereof, so that practically speaking, these men are making the wages of day laborers only.

What is the remedy? Deeper plowing and avoiding wasted effort.

Wasted Efforts in Farming.

It is wasted effort to endeavor to raise a crop on 3 inches of sod which requires 4 feet of root room. It is wasted effort to plow old land 6 inches and raise 10 to 20 bushels when by plowing 12 at an increase of cost of 50 cents an acre you can raise 40. It is wasted effort to try to save a crop by intensive cultivation when good plowing at the start would have assured a profitable yield.

It is often wasted effort to plant a crop in July which ought to be in by May, and to plant one in June which should be in by March; and yet these things are done on hundreds of farms. Cultivation at the proper time is absolutely necessary for conservation purposes; but after deep plowing it need not be nearly so intensive as cultivation after shallow plowing, and for some crops when the plowing is right, enough cultivation to keep the weeds out will often suffice.

It is waste of time and money to cultivate crops between rains; just in time for another crust to form and have to go at it again. Light rains and even wind storms will often restore the mulch by filling up the crevices through which evaporation takes place.

The Critical Period.

The time to cultivate everything, the most critical period in the life of the crop, is when the drouth sets in. This usually occurs at the end of spring rains, before the summer rains have begun; at this period everything should have a good mulch to carry it through the usual dry spell.

To cultivate corn or any other row crop every week or so just because the weather is dry is absurd; so long as there is a good mulch it should be left alone, for over-tillage will create dust which will only blow away or plug the interstitial spaces and prevent absorption when a storm arises.

Another point on the tillage question that we must consider is this: That although cultivation developes mineral plant food it burns up the humus, and since these effects are about a stand-off, we as dry farmers can afford to ignore all these functions of cultivating excepting the killing of weeds and the conservation of moisture.

The Function of Air in Soil.

We sometimes hear agriculturists say we must cultivate to get air into the soil. Of course, this is mere nonsense, a relic of eastern farming; we cultivate to keep the air out of the soil, for there is always more air than necessary to support bacterial life and all chemical combinations which may take place without trying to add more, but in the humid states it is conceivable that the surface may become waterlogged and air-tight, and this injurious condition may be relieved by cultivation.

Air moves more freely through a crust than through the mulch, but so long as the soil moisture is attached to the granules and the interstitial spaces are more or less clear, which is the usual condition of dry farm soil, there is absolutely and always some air movement and some evaporation, however slight, even through the mulch. We put the lid on by cultivation, but it is only a lid, it is not a cork in a bottle.

Lots of time and money may be saved in the spring by plowing just as soon as the frost is out of the ground, and even before this period sod may be disced on the surface after a thaw to make it easier plowing for the horses later on.

It is a money-making method to plow corn land deep in the fall and cross list in the spring; but failing this, March plowing for corn will increase the yield over May plowing by several bushels.

When corn land is plowed early nearly all the weeds, especially Russian thistles, can be exterminated before planting.

The cheapest way to clean up weedy land is to plant it for two years to fall rye; as soon as the crop is off it should be plowed and clean fallowed until the last of August, and then replanted about 40 pounds to the acre.

Plan Your Work Ahead.

The farmer should draw up his program for the year ahead of time so that he can foresee the work for each week, and almost for each day in the week and be prepared for it.

He can then alternate the crops so that all the harvesting or plowing or cultivating will not be necessary at one and the same time. For instance, as soon as the frost is out of the fall plowed ground in March he commences drilling in his spring grain; as soon as that is done he goes to plowing for corn and sorghum; while this land is fallowing and absorbing moisture, he plows up an area for winter wheat; by the time that is done he can clean weeds out of the corn and cane land; then alfalfa may be planted and after that, about May 15th or 20th, the corn can go in; by the time the corn is all in, the Kaffir corn, sorghum or milo may be planted; when that is done it is about time to harrow the corn, and after that the cane. If there is any fall rye it can usually be mowed for hay about this time, also the first cutting of alfalfa, and after this will come the cultivation of the row crops and a discing of the summer-fallow for winter wheat. The harvesting of the grain crops follows closely, and perhaps a discing or plowing behind the harvester. The season then closes with the cutting of corn and sorghum and the planting of winter wheat and rye.

It requires some careful thinking to plan the season's campaign, plant the right amount of each crop and arrange all these operations in their most economic sequence, so that one man or two with their teams, as the case may be, have their time fully occupied without getting up in the middle of the night, and without any dead time.

Adjuncts in Dry Farming.

Cattle and poultry are almost necessary adjuncts to the payable dry farm. A dairy herd is always a good investment if a creamery is handy, for the milking is done before breakfast and perhaps with a safe old plug the children can deliver the cream on the way to school.

A hundred chickens properly looked after will use up all the waste and buy groceries for a fair sized family, but if the accommodations are not ample, it will pay much better to keep fifty. Broadly speaking, any farmer can make chickens pay if he raises their feed, but to buy feed and then make them pay requires an expert, and chicken experts are about as rare as the dry farmer who plows 10 inches.

A side line for dry farmers who can keep going 16 hours a day is bees, for much of this work can be done in the evening, but the rewards are not always sure, for like fruit there are good years and bad years; nevertheless there is money in it provided the neighborhood is right; plenty of alfalfa and other bee pasture.

Keeping enough hogs to use up the skim milk is a good economy on any farm, and in places where there is a demand for young weanling pigs, there is money in two or three good sows. The rule to follow in this matter is: Get you feed first and then buy your stock; don't go ahead and stock up your ranch until you know what you can raise, otherwise you are almost sure to come out at the little end of the horn.

It isn't the stock that make the money, it is the feed you put into them, and since you require the best possible returns for your feed it never pays to feed or raise poor stock.

Plant the Best Seed.

For the same reason always plant the best seed, for there is nothing that will cut the profits so much as putting time and labor into raising half crops from poor strains, and it should be remembered in this connection that the most expensive seeds are not always the best. Seeds obtained from the farmer who raises them are nearly always better and often germinate better than those from the seed house.

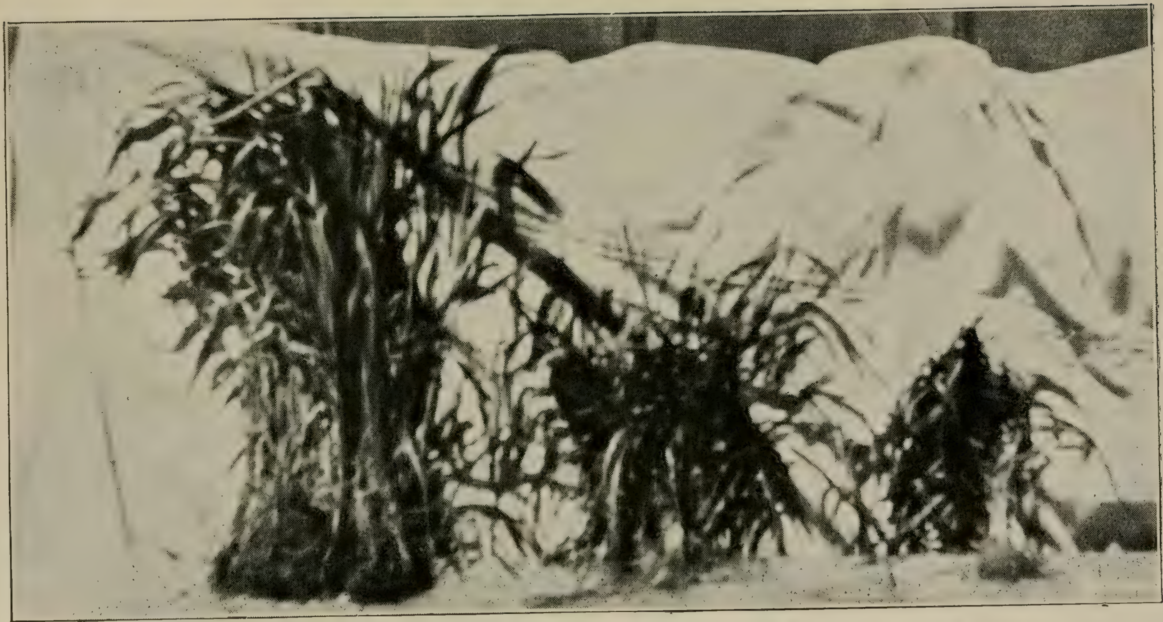
Alfalfa is a most profitable crop in connection with the dairy, it has to be planted only once; it grows while you wait, and if the gophers are kept out seems to last almost forever.

I hear one of our readers say: "I have tried alfalfa and can't make it go." I know, but try it again; ten acres of alfalfa will increase the valuation of your farm by $1,000.

If you plow 10 inches deep and your soil is good there is no question about getting a stand. It is a race between the roots and the drouth; if the roots get down ahead of the drouth the game is won; 10-inch plowing handicaps the drouth and gives the race to the roots.

The Dry Farm Orchard.

How about an orchard on the dry farm? If you are in the midst of a dry, bare country where there



Winter Wheat, May 1st on Sod Broken 8 inches, 5 inches and 3 inches Deep. Note the Excellent Growth Made on the 8-inch Breaking.

is no fruit for miles around, you can make money on the side by raising cherries.* People will flock in from hundreds of miles, camp at your place and go home loaded with cherries to put up for winter, and they never seem to get enough. This is how it works on my ranch, but it should be considered only as a side issue, I believe, for it is not safe to gamble on the climate—we may have four or five good years and then three or four bad ones, or perhaps a hailstorm. The cultivation of a 20-acre orchard will not cost in labor much more than $60 a year, and any year after the first six it may bring in $2,000 or $3,000 in one season.

On my ranch we sell our dry raised cherries for 15 cents a gallon when they run about ten gallons to the tree; when five or less we ask 20 cents, at which prices the buyers do their own picking, and glad to have the chance.

The hardiest and best bearers are the Montmorency and Morello, they commence to bear the year after planting, paying expenses almost from the start, and at five or six years old yield a heavy profit when the season is right.

Dry Farm Profits Greater Than Irrigated.

I believe the profits from the dry farm properly conducted are greater than those of the irrigated farm, for although the area has to be larger to raise the same amount of crop, the expense account is so much smaller, and so much less capital invested. The principal economic factor is deep plowing, the difference between 6-inch and 10-inch plowing will often double

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*It should be remembered that Mr. Parsons' recommendations as to varieties of fruit trees to plant on the dry farm apply to conditions in eastern Colorado. Our Horticultural Societies do not recommend cherries except for the southern part of South Dakota. In their place the hardy plums may well be used as well as the plum-sandcherry hybrids. In deciding on varieties of fruit trees to plant in your localities consult the Fruit List of your state horticultural society.

the crop, and comparing the two side by side in the same soil I find the following:

Deep Plowing Means Returns Every Year.

Although good fair crops are sometimes produced in good years on 6-inch plowing, yet when dry years come there is no comparison; the drouth cuts the crops the first dry year on 6-inch land at least half; on 10-inch land not more than 10%, while the second dry year will burn out almost everything on the 6-inch plowing, it will not cut the crops on the 10-inch more than half. This is not guess work, but exactly what happened in my neighborhood in Colorado in the two consecutive dry years of 1910 and 1911; precipitation on my ranch 8 and 6 inches, respectively, our normal being 14 to 15 inches.

CHAPTER XIII

Suggestions for Dry Farmers

I AM often asked the question, "Under what conditions do you believe in dry plowing?" The trouble in plowing ground dry is over aeration, too much air, and not enough water; but when water comes in it drives the air out, the clods are easily broken up with a little discing; the ground settles; becomes ready for planting.

There is nothing which will burn the crops more quickly than too much air, and it is a perpetual battle with nature for the dry farmer to accumulate enough water to drive the air out.

The agriculturists who come here from the east cherish two pet delusions: One is that capillarity will save the crop in dry weather by bringing up water from the subsoil as it does in the wet states; the other is that the roots of our crops need air. They don't know until they have run a dry farm that the subsoil is nearly always too dry for capillarity to act; neither do they know that our soils in a natural dry state may contain bulk for bulk 50% of air, and when dry-plowed sometimes 70%, and many of them will say get air into the soil, the roots of the plants need oxygen, and I believe it was Campbell who said get the right amount of air and water into your soil. This sounds very wise, but it is quite the reverse, for the relative amounts of air and water in the soil change every hour of the day, and until we can control the weather we cannot regulate the air and water; but we can modify the ill effects of the air by not planting until the ground is in condition.

Supposing we plow ground in the fall dry or half dry, the winter is dry, the soil is in poor shape in the spring, what are we going to do about it? The only thing to do is to disc it and harrow it alternately until a fairly fine surface is secured and then plant it, trusting to nature to do the rest.

Fall Plowing Usually Best.

The farmer will most likely say to himself, "I wish to goodness I had left this land and plowed it in the spring." But he will find that in a dry season if he plows in the spring the ground will be just as ill-conditioned as it was in the fall, and when he is through fining it down he will discover that the fall plowed land contains a little the most moisture. Therefore there is little or nothing gained by waiting, provided any kind of a fair job of plowing can be done; for if the snows and rains come, it will mellow down; if they do not, then the spring plowing will be just as bad if not worse.

Early Spring Plowing.

Supposing it is impossible for some reason or other to plow in the fall for spring crops, what is the next best thing to do? Disc the land as thoroughly as possible and then plow in the spring as soon as the frost is out of the ground.

It is always an advantage to fallow the land between crops if only for a month or two. The field plowed in the fall for corn to be listed in in the spring will usually beat any land for yield which is plowed after the winter, and the field plowed in March will, in nine cases out of ten, be ahead of the field plowed in May.

In raising a crop on sod the great trouble as usual is air. The shallow plowers try to get around this by rolling the sod flat and then harrowing the surface. This is good as far as it goes, but there is a certain objection to it, it doesn't raise crops. When I see a field of this kind it always puts me in mind of planting crops on a rag carpet.

Deep Plowing Excludes Air.

If the sod is plowed deeply, from 8 to 10 inches or more, we get a larger proportion of soil to the roots, the soil is on top, the grass and roots underneath. The sod is pressed down and the surplus air excluded by repeated discing and harrowing until the surface is fine and well mulched. The disc cuts the sod and forces it every way, jamming the little pieces into every underground hole and corner until the seed bed is fairly solid. While this work is progressing underground, the surface is becoming finer and more impervious to air every minute.

A sod seed bed prepared in this manner often raises the banner crop of the same piece of land. Air spaces underground are always to be deprecated; but their injurious effects are much reduced by a good mulch.

Air in circulation is ten times as deadly as stationary air, because it carries all the moisture away with it. So long as there is plenty of moisture in the soil the air movement is up and out, for a cubic inch of water makes 1700 cubic inches of steam at 100 centigrade, but even at the temperature of the soil the expansion is enormous.

The atmospheric pressure at sea level is between 14 and 15 pounds to the inch; in Dakota probably about 12, for the higher we go the less atmosphere to press down on the earth. High altitudes therefore favor evaporation.

Winter Wheat Following Corn.

A farmer asks this question: "Is it safe and advisable after taking off a corn crop to disc it up and plant winter wheat?"

As a general rule, no; but at the same time if the plowing for the corn has been 10 inches deep, the cultivation kept up, and the season wet, it is quite possible a good crop of winter wheat may be obtained. Every farmer ought to carry a soil auger to test his land, then we could give a definite answer to this question. If there are 5 inches of available moisture in the top 4 feet, over and above the hygroscopic coefficient, and the precipitation holds to the average up to time of maturity, a good crop of wheat could be raised.

If the indications are that the corn has used up most of the moisture, it would be much better to plow the field and winter-fallow it for spring planting. On the other hand, if the farmer is bound to plant anything, it had better be rye, for I have never known a season in which fall planted rye did not make a good crop of hay, and if the season is very favorable a crop of grain even on corn stubble without plowing.

Planting on Stubble Not Advised.

I never advise planting on stubble without plowing because it is a mighty bad habit to get into, and a good crop in an exceptional year has been the undoing of more than one farmer.

There is nothing so important in our new agriculture as to keep a level head and try things out as we go. We are surrounded on one hand by faddists, men who dream dreams, and sit in their offices dry farming in their minds, and on the other by a set of agriculturists who seem determined to run the dry farms by the ancient and holy text books of the east.

A man came to me once who said he had been reading some literature which said all you had to do was to plow a few inches and pack the land and all the moisture necessary would come up from the subsoil and nourish the crop. So he went to dry farming with a packer and a disc. At the end of the season by trailing a canvas behind the mower sickle he managed to gather one load of oat hay off ten acres.

Discing Before Plowing.

A correspondent asks: "Which is the best, to disc the surface of a field before plowing or to put in the same amount of work in cultivating the crop later on?"

It all depends; when the crop has been taken off, and for some reason or other it is not plowed, it should at all events be disced to hold the moisture until it can be plowed. On the other hand, there is no particular object in discing a piece of land today and plowing it tomorrow as it would not increase the yield to any appreciable extent when the land plows in good tilth.

But supposing the land is dry or half dry? This is the time when discing pays, because it creates a few inches of loose dirt which when turned under helps to fill up the air cavities between the clods.

Discing Before Breaking.

Does it pay to disc sod before plowing? Always, the only possible exception being when you use a Spalding deep tilling machine, but even then it makes things easier for the horses; but when plowing with ordinary walking plows it makes a difference of almost one horse to the plow if properly and thoroughly done. The time to disc sod as a preparation for the plow is when the weather is too wet to do anything else. Except in the worst kind of adobe, sod seldom sticks to the disc no matter how wet it is, and the moister the ground the more easily can the disc cut it. Discing sod not only helps the horses later on, but when turned under helps to fill up the air spaces next to the subsoil and makes a more compact seed bed.

After plowing if the sod is again disced on the other side there will be little of it left to bother the farmer, not much left to rot. The only disadvantage connected with this method is as an old friend of mine said: "When I used to plow the sod and leave it to rot I always had lots of time to go fishing, but now I have to stay home and cultivate crops." No doubt he had less fishing, but his family had more clothes.

When a man asks, "Do you think I can succeed at dry farming?" I always feel like saying, show me what kind of a seed bed you can make out of sod and I will tell you.

Crops Not Made on Seed Bed Alone.

As an objection to deep plowing it is often urged that the top soil may be ruined by plowing up something deleterious. How can we tell if this is likely to prove the case? The fact is no crop to amount to anything is ever made from the seed bed alone. The roots always go into the subsoil unless dry weather or shallow plowing prevents them, and when this happens there is no crop.

The average depth to which the roots of grain plants go down is about 3 to 4 feet, so that probably one-half or two-thirds of the crop is made from the subsoil. Therefore, if any farmer has been raising crops on his place the subsoil must be right or he couldn't raise them, and it would be perfectly safe to go down a few inches farther with the plow.

The old idea that a crop was raised in the seed bed like a geranium in a pot and that we should pack the soil to draw the water up to their roots by capillarity from the subsoil is one of those ideas which we can relegate back to the dark ages where it came from. When the ground underneath the plow sole is tough and refractory as it is apt to be after plowing for years at one depth, it can be deep plowed and winter-fallowed to reduce the lumps; but if humus is needed to keep up the physical condition of the seed bed, it can be secured by plowing under a green crop, or by holding it for winter wheat planting, after plowing under a weed crop in June.

How Fast Does Water Escape?

I was asked the other day if I could give any information as to how quickly the water dries out of the soil. This, like so many other happenings, depends on conditions. An inch of water will go into some sod only 2½ inches and dry out in a little over a week, for the top inch of sod will hold about 100% of water until it evaporates into the atmosphere and is lost; for this reason the unbroken prairie gathers no moisture. When sod land is wet down to about 2 feet, which is as deep as the water usually ever goes on the prairie, there will sometimes be some left in the bottom foot as late as July or August. On cultivated fallow land it makes all the difference as to whether the soil is clay or sandy loam. When the latter is holding 3 feet of moisture to its full holding capacity, say 15%, and another storm precipitates one-half an inch; in sunny weather and June temperature the top inch will dry out in about a week; by that time the free water from the second and third inch will have passed upwards and disappeared and all that soaked downwards below the second or third inch will have worked down into the subsoil and become film water. The evaporation can then go on only through the interstitial or air spaces which is very slow, especially at that depth.

Deep Plowing Conserves Moisture.

Then if a 3-inch mulch is made by cultivation the loss by evaporation through the interstitial spaces will be approximately as follows: In the top 6 inches the percentage will drop from 2 to 3 points a month as long as the weather continues dry. In the subsoil 2 or 3 feet below the surface under 12-inch plowing the percentage dropped in five months dry weather from 15 to 14⅛, while on a neighboring farm under shallow plowing it fell from 15% to 12¼%. During this period no rain appeared which went in more than an inch.

When it is raining on and off there is always more water in the top 2 feet than anywhere else, but after a long dry spell conditions are just the reverse, and I have known the seed bed to dry entirely out while the dirt in the subsoil would ball in the hand. Thus we perceive that the water escapes to some extent even through a dry mulch but very slowly indeed by evaporation, as an old farmer friend of mine used to say the ground steams. If we take a pane of glass and place it on the dry mulch, putting dirt along the edges to keep the outside air out and then put a piece of ice on it the vapor coming out of the earth through the interstitial spaces will condense in big beads on the lower side of it. When conditions are right it will do the same thing on a board which will be wet on the underside after a cold night without any ice.

Distillation Instead of Capillarity.

Notwithstanding the fact that those following the old agriculture would call this capillarity; capillarity has nothing to do with it, it is the result of distillation —condensation, and is caused in the same manner and is the same thing as dew. The proof is that water cannot pass through dry earth without wetting it even by capillary action; but water as vapor—in the aeriform state—can, and these results may be obtained when the surface of the ground is dry and stays dry throughout the experiment.

As explained above, the loss from the subsoil by evaporation through the interstitial spaces is very slight, but such as it is, it is much greater under shallow plowing than under deep, and the logical conclusion in this matter can only be that the plowing acts as a mulch to the subsoil.

CHAPTER XIV

Seed Selection and Corn Breeding

A QUESTION the dry farmer often has to consider is this: Will it pay him to pay extra high prices for seed supposed to have been raised for a year or two under dry conditions, or for seed of some special variety of a hay, grain or forage?

Evolution teaches that it requires years and years for plants and animals to adapt themselves to a new environment by undergoing structural changes—changes in their make-up of a constitutional character.

Functional Changes.

On the other hand functional changes may take place in a comparatively short space of time; it all seems to depend on the potentialities hidden in the plant, and we know so little of the fixed laws which govern these eventualities that it is impossible to predict without trying it out, what may happen, or may not happen to a plant or tree in a new environment. By a functional change we mean a change in its method or action, not a change in its structure or make-up; for instance, supposing a plant on being moved from a wet climate to a dry one were to develop the faculty of turning its leaves edgewise to the sun to lessen transpiration of moisture; this would be a functional change. Thus if we raise a certain crop for a number of years under dry conditions, it may gain something in drouth resistance, or it may gain appreciably nothing. I say appreciably nothing because it is a law of evolution that nothing exists even for a small space of time without its environment so to speak leaving its mark; but this mark may be so infinitesimal in one or two seasons, as to be practically indiscernible; but the sum of all these marks after a number of years may amount to something in modifying the nature or structure of the plant to enable it to resist the encroachments of its new environment.

Drouth Resistance Evolved.

Therefore practically speaking, every year we raise a crop on dry land, and save the seed for replanting, we are forging a link in the chain of drouth resistance, but whether this link is worth much we do not always at once know, whether the chain is a long one we cannot tell, but we do know that some impression however slight is being made and that eventually these impressions as a whole will show results.

For these reasons we believe that although there may be no particular object in paying exhorbitant prices for dry raised seed, when good irrigated seed can be obtained; yet it will certainly be much safer and pay better in the long run to purchase dry raised seed and save it every year if only for the good it will do ourselves, and the country at large to forge one or two links in our chain of drouth resistance.

"Run Out" Seed.

We often hear farmers say, "Oh that seed has run out in our neighborhood; it is no good any more."

Now what is the trouble? There are usually two good reasons for this. One is want of proper selection; the other, the necessity for crop rotation; the land becomes crop sick; the grain deteriorates.

The longer any crop is grown in a given locality the more it becomes adapted to its environment, and the better it does, provided we give it a fair chance with regard to the above two factors—selection and rotation.

Why is selection such a potent force in seed raising? Because everything we raise was originally derived from a wild prototype, and the tendency under the slightest adverse condition is to revert. Therefore in order to maintain a high standard of excellence, we must provide not only the very best conditions of seed bed and culture; but must select the very finest of the stock for purposes of perpetuation or breeding.

Dry Farming Old.

Dry farming, although they perhaps do not call it that, has been carried on for hundreds of years by the natives of the dry districts of Asia, Europe and Africa, and these are the places to look for drouth resisting grains, grasses and legumes, for the essence of adaptation is time, and for that reason we are much more likely to import a drouth resisting type than to evolve one.

Our macaroni wheats, the Turkey Red, the Mexican Peanut, the White Australian corn and other types were acquired in this manner.

As far as breeding is concerned I have dabbled in crossing grains, fruits and flowers, but my principal experience for over 25 years has been with corn; but before going into details in these matters, it is well to begin at the beginning and gain some insight into the laws of nature which govern them.

How Plants are Fertilized.

The perpetuation of species in plant life depends on sex, the commingling of the male and female element, just as it does in the animal kingdom. The majority of flowers and the blossoms of fruit trees are bi-sexular; that is to say, both sexes are represented in one blossom. In the center of the blossom we find the pistil; at the top end of the pistil like a little flat disc is the stigma; all around the stigma are the pollen bearing anthers; the pollen drops from the anthers onto the stigma; this fertilizing element from the stigma is carried down the pistil by the sap into the seed pod where the stem joins the blossom and lo the pod begins to develop into a cherry or plum or apple as the case may be. Some blossoms, however, like those of the pumpkin are not bi-sexual but either male or female, and for fertilization purposes the pollen must be carried by insects or wind or some other agent from the male to the female blossom.

Sexes Individual.

In some trees and plants we find the sexes individually apart, or as it is called dioecious; a male tree which provides male blossoms but no fruit; a female tree which has female blossoms but fruits only when there is a male tree in the neighborhood to supply the pollen brought to her blossoms by the insect carriers or the wind.

Corn is fertilized by the pollen from the tassel falling on the silks, for there is a silk for every grain of corn, and if the pollen does not fall on any particular silk, the result will be a corresponding blank on the cob. Corn is therefore largely self fertilized or inbred, a characteristic which we will touch upon later.

Besides the laws of sex the other most important ones involved in plant breeding are the unit quality or characteristic law, the Mendel law of reversions, and the law of variation, mutants or sports.

Burbank and De Vries both agree that in crossing two different varieties or types, the qualities or characteristics of either parent when transmitted to offspring are not, as a rule, merged or blended, but are passed on as a whole or unit.

Thus if we cross yellow corn with white we do not obtain a cream colored corn; but ears containing some yellow and some white grains all on the same cob. The same with earliness or lateness, for when we breed an early corn with a late one, the first result is that the corn is not medium, but each plant is either early or late according to the parent which it takes after.

Mendel's Law.

The Mendel law which was in fact a law of reversions, not entirely understood before he elucidated it but yet practiced by animal breeders to some extent, gives us the exact ratio in which reversions take place under a condition of inbreeding. This law says: If two varieties are crossed and the first generation allowed to inbreed the resulting progeny will throw back to the original type; three of the dominant type to one of the other. Supposing, for instance, we cross the White Australian with a common white corn of weak potency; then the White Australian will be the dominant type of the two. We take the seed from this cross and plant it and raise the plants in such a manner that they must inbreed from the pollen on their own tassels, then save the seed and plant it the following season; the result will be three plants of White Australian to every one of the other.

The inbreeding has caused the mixed or crossed corn to revert to the original types in a ratio of three of the dominant type to one of the other. The moral of this is that if we wish to establish a new type by crossing, we must allow no inbreeding until seven or eight generations have passed and the new variety breeds true. Many a man has paid hundreds of dollars for an ear of corn only to allow it to inbreed and revert; whereas if he had purchased at the corn show one ear of the same variety from each of two different farmers and bred them together, the odds are that he would have produced a finer corn than either one. Many corn breeders understand this and do not mind parting with their best ears for they know nothing will come of it.

Law of Variations.

The law of variations or sports or as much as a farmer needs to know about it is simply this: The rule that pure-bred stock should breed true has its exceptions, and while it is true that these exceptions which we call variations, mutants or sports, are somewhat rare it is nevertheless a fact that they occur, and are of the greatest value to breeders in obtaining new types.

Cross breeding seems to have the effect of stimulating all the latent potentialities and dormant possibilities in the creation of these sports, and in a field of cross bred corn we may discover at any time valuable ears which seem to bear little relation to either parent, and in points of excellence may transcend anything in the field; but this is the point to fix in our mind: It is possible that from these we may derive an entirely new and valuable type.

Nearly all of Burbank's new and wonderful creations have been obtained in this way, not by the old method of selection alone, but by cross breeding, and the selection of promising sports. In breeding from sports we must not forget the law of reversions already explained; we may find a magnificent ear of corn and lose the value of it entirely by allowing it to inbreed and revert. To prevent this we must breed it with the next best ear we can find in the patch, and do the same for five or six years at least until the type becomes more or less fixed, the idea being to prevent the corn from becoming fertilized from the pollen off its own tassels.

Preventing In-Breeding With Corn.

How is this done? By planting the two side by side and detasseling the most valuable; this makes the corn from the best ear the female parent, and the next best ear which provides the pollen the male parent. Whole rows may be planted side by side and one of them detasseled, in fact all corn for seed should be beheaded in this manner whether for breeding purposes or not, for the reason that cross pollenization produces stronger and more vigorous seed in anything and everything than self-fertilization. When the tassel is cut off a hill of corn we are absolutely sure that the silks must then be fertilized from the tassels of a

Orchard of Yellow Transparent on the Dry Farm of E. R. Parsons, Eastern Col. Average Rainfall 14 or 15 ins.

neighboring hill or not at all; but as a matter of fact they always seem to catch the necessary pollen and if only the one variety with which we wish to make the cross is planted immediately adjoining, the results are certain. Some breeders will declare that inbreeding instead of causing reversions helps to fix the type. The truth is, in pure-bred, blooded stock, inbreeding does do this, but in cross-bred stock it causes reversions by throwing back to the dominant type. The first year when making the cross we plant the two varieties side by side one row of each and then detassel one row. If one variety is 90-day corn and the other 100-day corn, then the latter must be planted 10 days ahead to insure their both arriving at maturity at the same time.

Seed From Detasseled Rows.

The second year we collect the ears from the detasseled row and in order to prevent inbreeding we take only one grain from each cob and again plant two rows, detasseling one row; either will do.

The third year any of the grain can be planted from the best ears; but the rows intended for seed should always be detasseled, at any rate for six years.

The yield is kept up by selecting the most vigorous and by detasseling the seed row; it can often be still further increased by making a fresh cross; it will then be a compound cross.

A cross or a compound cross is not a hybrid; if we could cross corn and wheat it would be a hybrid; but hybrids, like the mule for instance, do not perpetuate their species except in very rare cases.

In these things and many other characteristics, the vegetable kingdom and the animal kingdom are analogous.

Unit Quality Law Valuable.

The unit quality law is of great value to breeders inasmuch as it allows them to impart to one variety any particular characteristic of another. Supposing, for instance, we have three different varieties of corn; one possessing the earliness we desire, one has an extra fine color, another has extreme hardiness and vigor, and we wish to combine these characteristics in one variety; how do we set about it?

We cross the first two and obtain a new strain, then cross this with the third variety which results in a compound cross, then we plant as large a number as possible of the latter, selecting and propagating any of these which combine in the highest degree the three characteristics we demand.

We may find only one or two out of thousands that fulfill these requirements, but they can always be obtained by persistent efforts.

If it were not for this unit quality law, earliness would merge with lateness, color with color, vigor with weakness, and so on resulting in a negative mixture neither one thing nor the other. Burbank considers this law one of the most important in the creation of new varieties.

Farmers Should Watch for "Sports."

All farmers should be alive to the value of sports or variants; it is from these that the great plant breeders have derived so many new and wonderful varieties. Anything promising in this line should be separated from the common herd and bred with as little inbreeding as possible until the type breeds true.

Flowers and fruits are crossed by bringing the pollen from one blossom to the other, and then propagating from the seed, selection always going hand in hand with crossing. In order to cross small grain the flowers have to be emasculated; the male and female organs are so close together that self-fertilization will take place unless the male element or pollen is removed, when the pollen from the plant desired for the cross can then be introduced. The accidental intrusion of foreign pollen not desired may be prevented by tying blossoms in cheese cloth.

Suggestions for Corn Breeding.

In breeding new varieties of corn, I believe it best in the west to select chiefly for earliness and quantity, for after we have achieved these results, will be time enough to take up breeding for beauty and fancy points.

The idea of not too large a cob is all very well, but to breed it almost entirely out would be a distinct disadvantage, for it fulfills a very useful purpose by holding sufficient moisture to mature the grains in the shock after the growing season is practically over.

Big ears, as every farmer knows, do not always mean big yields, and the man who takes the prizes at the fair may be raising only ten bushels to the acre.

The same thing may be done with wheat by screening all the big kernels out of a large acreage of poor grain. If we wish to stimulate the introduction of better methods, we should give prizes for yield, not for specimens.

Planting on Dry Farm.

In the corn contests the greatest yields have been obtained (over 200 bushels) by deep plowing. Every inch counts, and in dry farming it is better never to plant more than one in a hill. The distance apart should be largely determined by the depth of plowing, 2 feet being none too much with a 7-inch seed bed, but with 10-inch plowing, 18 inches will suffice, and with 15- to 20-inch plowing an enormous yield was raised by planting 1 foot apart. When corn commences to run out, new blood is necessary, almost any kind of a cross will produce larger ears and increase the yield, but if a mongrel type is not desired, the same old variety can be introduced from a neighboring farm and allowed to mix naturally by planting together.

In testing ears for seed we must always remember that one side of the ear may be good while the other side which has been leaning against the shock may have been damaged by mildew, therefore one grain from each ear is hardly sufficient unless we are very careful to pick only the brightest and cleanest. Seed corn should not be exposed to below zero weather; the trouble is the germ can absorb from the atmosphere as high as 20% of water and the expansion from freezing is liable to rupture the cells and destroy its germinating power even when the corn seems to the farmer to be perfectly dry.

CHAPTER XV

Listing Corn on the Dry Farm

CORN is one of our standard dry farm crops. Everyone raises corn or fodder, and some consider it a safer crop than sorghum, and it is some years; but since it is impossible to forecast the weather the farmer seldom knows which will make the best and most feed until he has it harvested.

In hot dry years the cane usually does the best; but when the season is cool and backward and not so dry, the corn fodder may come out ahead.

It is not good policy to try to raise corn and fodder as one and the same crop. To mature grain the plants must have plenty of room, and the ears should be left on until the leaves are brown. To raise good fodder it should be planted thickly and cut at the first sign of browning up.

It was ascertained some years ago by experiment that the farther apart each grain was planted in the hill, for it was all hills in those days, the better the yield; this, of course, eventually led to row planting, and the old two-way check row system was abandoned by the progressive growers.

The Corn Lister.

Then the lister came to the front, which will drop the grains any distance apart the farmer may desire in the bottom of a furrow, which it makes as it goes.

This implement was hailed with delight by the surface farmers and those who hated to plow. "Here," they said, "we have a machine that plows and plants at one and the same time, we can run over ten acres a day." So they did, and so many of them are doing yet—planting corn in the hard ground, raising ten bushels to the acre and telling everybody their state was never intended to raise corn in and never would amount to anything for that purpose. The lister, however, properly used is the best implement known to man for raising corn on the dry farm where depth is the prime factor, for it plows a furrow, and then plants the corn in the bottom of it. By this method the roots of the corn are established at considerable depth close to the subsoil, and down they go right into the moisture, thus evading all danger of stunting by drouth.

Another point, as soon as the corn shows up well above the top of the furrow we take the cultivator and running close to the corn, fill it up, thus completely burying all the weeds in the corn row, and saving a whole lot of hoeing.

When the furrows are filled up and the field leveled by the cultivator the corn is set in the ground 5 or 6 inches deeper than by any other method now in use. It has the advantage not only of being closer to the moisture, but of possessing more strength and stability to withstand flood, and wind, and a 3 or 4 or even 5-inch mulch can be put on at almost any time with the cultivator without danger of injury to the roots.

Root Pruning in Surface Planting.

There is this to remember about corn: If you plant it shallow and allow the roots to occupy the surface, and then cultivate deep, you are very liable to ruin the chances of a crop; but if on the other hand you give it a good deep root system by listing, cultivate deep and keep it up until the last minute, it will not hurt the corn a particle, but by cutting off the incipient surface roots will cause it to go down deeper and deeper.

If the corn, however, has been laid by, and you should determine late in the season to cultivate in rye, for instance, the rows between to be turned under the next spring for fertilizer, it would be better to cut shallower with the cultivator, for when corn is not tilled it will always send out a mass of surface roots and it would do more harm than good to destroy them near maturing time when they are helping to make the corn by catching moisture from light showers which never wet the subsoil.

Lister Not to Substitute Plow.

The lister is not a plow, and was never made to do a plow's work, it is simply a variety of corn planter and should be used as such.

To raise payable crops of corn, something that will pay for the labor expended and something over, it is necessary to plow from 10 to 12 inches deep and list the seed in across the plowing. It matters little, then, how dry the weather is so long as moisture has been conserved in the subsoil. It often takes three months continuous drouth to dry out the top 6 inches; at planting time the corn when listed is already in this deep, and three weeks later the roots will be down another foot, at least 18 inches in all, and by the end of the season, if we take the trouble to exhume some of these, we will find some probably 6 to 8 feet long.

Spring or Fall Plowing.

Here comes a question: Should the plowing be done in the spring or the fall?

It depends on the soil. Corn is not like oats and wheat, it has a "rooted" objection to hard land. Some soils settle and show much more sinkage at the end of the winter than others, and these hard soils often show better results when plowed early in the spring. Light soft loams, however, are better plowed in the fall.

It is a mistake to plow land at the last minute and plant behind the harrow. Corn land which is not plowed in the fall should be plowed as soon as the frost is out of the ground in the spring, and the first weed crop can be disced out before planting, which gives us a cleaner field.

The next best thing for putting in corn, when the lister is not used, is the split wheel planter, the vacant space in the center of the wheel leaving an unpacked streak for the shoots to come through. When the spring is cool and backward it is better not to plant corn more than 2 inches deep. I have known it, however, to come through 8 inches of soil when the weather was warm.

If the land is plowed in the fall or early in the spring it needs no packing except in the seed row, and not very much in that.

Distance Apart in Planting.

How far apart should the grains be dropped?

The idea is to space the kernels one by one in the seed row according to the fertility of the soil, the depth of plowing and the outlook for moisture.

When the moisture conditions are right an enormous crop may be made by plowing 20 inches deep, and planting a foot apart in the row; with 10 and 12-inch plowing, 18 inches apart; with 8 to 9-inch plowing, 2 feet apart. When the soil is poor the seed may be planted one in a hill 36 inches apart by check rowing and cultivating both ways.

There is no harm in fertilizing corn in the row if the owner so desires, and in some soils this will pay for the fertilizer many times over. Finely ground phosphate rock or bone meal with some nitrate is used for this purpose, and so little is applied that there is no permanent effect noticeable on the soil.

We have to be careful with nitrate in large quantities in some soils, but ground phosphate rock which is chiefly lime, if pure, is invaluable to any soil which does not contain it in moderate quantities, and this is probably the first element that our western farm soils will become deficient in.

Importance of Strong Seed.

In planting corn by the single kernel method with the lister or planter there is one point we have to be very careful about, and that is to test the seed for vigor so that every grain germinates. If the seed is poor and purchased in bulk instead of in the ear, the only way around this problem is to drop two grains instead of one, and when they come up cut out the extra ones. The thinning by hand might cost 50 cents an acre or more in labor, but it would be worth it to obtain a good stand.

The average yield of corn in the west is something like 13 bushels per acre. By the methods outlined in this article this may be increased to 40 or 50 bushels. This is no fairy tale but fact, and the writer would be pleased to refer any skeptical reader to those who have done it. Forty bushels per acre is no extraordinary yield even at 6,000 feet altitude, and in this connection I would say, stick to corn, don't be afraid of it, for history of this grain shows that it can be adapted to almost any climate from the arctic circle to the equator.

To obtain the best seed corn, detassel four or five rows in the very best part of the field, leaving the tassels on the alternate rows.

Variation in Kernels.

No two grains on any single ear ever produce exactly alike, each grain is a distinct and separate entity; for instance, supposing the farmer is raising a white corn, and when saving the seed he notices some yellow grains mixed in with the white, which sometimes happens when the wind brings pollen from another field; all he will have to do to keep the strain pure will be, not to discard the whole ear, but simply to cut out the yellow grains.

The principal reasons for poor germination are harvesting before the seed is matured, becoming moldy in the shock, and exposure to excessively low temperature in winter.

The only objection ever urged against listing is that where the ground is not level an early cloudburst which is very unusual, except adjacent to the mountains, may sometimes flood the furrows and smother the young corn just as it is coming through; but this is a contingency so remote as to be almost entirely ignored by the majority of the corn raisers.

CHAPTER XVI

Winter Wheat on the Dry Farm

THE dry farmer who understands his business never raises spring wheat where winter wheat flourishes. The average for the United States for 1911 is for winter wheat 14 bushels per acre; for spring wheat 9.

The reasons for this are patent to everybody. Winter wheat has plenty of time to root deeply, which it does more than spring wheat; the field in which it grows has all winter to catch snow and accumulate moisture; when the growing season commences it is already established, and can make its growth in the cool weather of late spring, and early summer, before spring wheat has hardly started.

Summer-Fallow.

Does it pay to fallow? I believe it does. I can point to several gentlemen of my acquaintance who raise their 40 and 45 bushels per acre by deep plowing and fallowing.

Besides these, there are several large communities of farmers who do nothing else, and make it pay. I know of men in the San Joaquin Valley of California who started in with little or nothing, twenty or thirty years ago, and are now worth over $100,000 or more. The product of this valley runs into the millions and the precipitation is only about 12 inches, sometimes 6 or 8; but the summer-fallowing which has been used in California for 50 years and more, equalizes the moisture, and allows the farmer to carry over a goodly percentage when the year happens to be a wet one. This method is considered such a sure crop producer that wheat lands without the possibility of any irrigation whatever are selling from $100 to $200 an acre.

This shows the true value of dry farm land with a sparse precipitation when properly farmed, which years ago was considered desert, and could be bought for 25 cents an acre.

There is also a summer-fallow wheat belt where, if I remember rightly, they told me their product was over a million dollars annually, and that is in the Blue Mountain district of eastern Oregon; the farmers there are also doing well and building up the country. There are others in eastern Washington and parts of Montana.

It pays much better to raise a crop every other year on the same piece of land which will run to 40 or 45 bushels than to raise one every year with double the work of 15 or 20 bushels. The reader may think my figures are too high, but if he will plow a good 10 inches, and summer-fallow, he will find out something about good plowing and yields.

Deep vs. Shallow Plowing.

The International Institute of Agriculture reports the averages for Belgium, England and Germany as 38, 33 and 30 bushels respectively. In the United States, the Department of Agriculture says, 14. What is the answer?

These countries plow from 10 to 20 inches. Our average all over America is 6 inches! Someone might say that the factor of fertilization intervenes; it does in this way: Our land is new and virgin soil hardly needing anything in that line yet—theirs, some of it, has been farmed for a thousand years.

Out of 38 bushels raised in Europe, about 8 would go for fertilizer, leaving a clear 16 bushels over and above our average yield.

Some of our college men are disposed to discourage wheat raising by our dry farmers, and they are right in a way, for if they approve 5 and 6-inch plowing, and this summer-tilling, as some call it—making a dust mulch with a harrow—there is little or nothing in it but a hand-to-mouth living; but that is not the way to raise wheat.

Value of Disc in Dry Farming.

The best method of preparing the fallow is to plow 10 or 12 inches, and disc and cross-disc without lapping.

Every farmer knows that the disc leaves two distinct ridges at its outside edges, as it moves along; now when we cross disc, we have the cross ridges which divide the whole field into checks, or squares, which will hold water. This is the easiest way there is to catch a cloudburst or quick rain; for these squares will hold an inch of water if it comes in 20 minutes.

In experiments made by Professor Farrel, an inch of rain went into summer tilled land less than 2 inches. In land prepared with the disc, it will go in 5 or 6.

To scratch winter wheat, late in the season, into corn stubble land, is also another favorite method of gambling with nature; but failure by methods which court failure is no argument whatever against raising this crop by profitable methods. In fields which are planted to wheat without rotation, fertility is as great a problem as moisture.

Nitrogen Need Not Decrease.

Some years ago, the magazines almost started a panic among the consumers by printing scare articles about using up all the nitrogen in the soil, and figured out how long it would take for us all to starve to death for want of wheaten bread. These articles, although written in some cases by eminent professors, were great nonsense. It has been found by 70 years of experimenting at Rothamsted, England, that when land is fallowed, its nitrogen content increases steadily. Besides fallowing, it may also easily be acquired by plowing under green crops, and for these reasons nitrogen will not be the first element of fertility to be missed from our soils. From present indications, phosphoric acid will be the one, and when the demand becomes insistent enough to guarantee a reasonable profit, the phosphate rock will be supplied from our own mountains right at hand, which contain any quantity of it.

In California, the practice of heading the wheat is much to be commended; this leaves all the straw and stubble on the ground to be plowed under or pastured to stock, for whether it is plowed under as straw or manure, it remains in the field, and is converted into humus.

Treatment of Land Following Removal of Crop.

A question, however, with those who bind their wheat and leave a 3 or 4-inch stubble is this: Should the ground be disced behind the binder, should it be plowed, or should it be left as it is?

In answering these questions we would prefer to have a reliable forecast of the weather; in place of this we can only bank on what it should be in order to conform to the general average conditions of the district in question. For instance, if the winter should prove warm and dry, a good discing would save much moisture; but should it prove windy and snowy, the stubble by catching the drift will accumulate more moisture than the discing could conserve. It should also be noted that by carrying the field through the winter in the stubble, the labor of one discing is saved; then if the straw is needed for feed it can be pastured towards spring.

The cattle, of course, eat off the stubble, but return it all to the field in the shape of manure, and the trampling and the dust plug up the cracks and prevent loss of moisture almost as much as a mulch; but as soon as they are off, the disc should be run over the field to cut up the surface, bury the manure, and plant the weed seeds left in the stubble. Then when the weeds are up 8 or 9 inches high, is a good time to prepare the summer-fallow by plowing everything under 10 or 12 inches deep in May or June. The fertilizing effect of the weeds in producing humus when plowed under will more than offset that lost in discing the summer-fallow.

In raising winter wheat, the yield depends on the depth of plowing, and as to whether the land was fallowed or not.

Pays to Plow Deep.

Some say, of course, that it does not pay to plow deep, but if these gentlemen were to plow a few acres 10 to 12 inches deep, they would soon understand that by plowing shallow they are robbing themselves of something like 10 or 15 dollars per acre.

Here is a case in point. Five or six years ago an engine came through a neighborhood with which I am familiar. One man hired the owner to plow him up 20 acres 5 to 6 inches deep at $2.50 per acre; another hired the same outfit to plow 30 acres 9 to 10 inches deep at $4.50 an acre.

Both plowed in the spring and planted in September; both cultivated about enough in the interim to keep the weeds out. The field plowed 10 inches deep yielded 38 bushels to the acre; the one plowed 6 inches went 23. The extra cost of the deep plowing was $2 an acre, the extra yield 15 bushels worth 90 cents a bushel, which equals $13.50; deducting the $2 an acre for the extra depth plowed, this man made $11.50 an acre clear profit over and above what the shallow plower made, without doing a thing except to give his instructions to the engine man.

Did it pay or did it not?

Wheat On Sod.

Now about raising wheat on sod? On thin land, it is often the best crop for the first few years.

Anything can be raised on sod; it is simply the same old axiom—more work, more returns. Do we want to put in $5 worth of work and take off $7; or would we rather put in $10 worth and take off $20 or $25?

Everyone knows the first of these methods—the sod is plowed 2 or 3 inches, rolled flat and a slanted harrow run over it; the yield—well, the less said about that the better.

The other method is to turn under the sod from 8 to 10 inches deep, thus saving all the humus, and disc and harrow alternately until the surface is fine enough to cultivate.

Lots of work! Yes, certainly, but the yield! It may cost 14 bushels per acre in money to do this; but the returns will be from 25 to 40, according to the season, and there will be no sod to bother next year as there always is when it is left on the surface to dry out.

Variety to Sow.

What kind of wheat would you plant? Sometimes we find a locally raised grain that is immensely popular with the farmers and does well, but the wheat most universally raised and the one to be found at nearly all the exhibits from Canada to Colorado is Turkey Red.

The great value of this wheat consists in the fact that it is almost as hardy as winter rye; the grain is elongated, and not so thick as some varieties; but weighs up well and produces an enormous number of heads to the plant. It could easily be crossed with some variety of plump Russian spring wheat by planting the latter early in the season under glass, and if the weight of the grains could be increased only 10%, it would create quite a difference in the yield. The result of the cross would naturally be some winter wheat, and some spring wheat, but the latter could easily be eliminated by planting in the fall, the survivor being the winter wheat.

Ben Davis Orchard on the Farm of E. R. Parsons, Colorado.

Farmers often complain that when they use their own seed for a number of years, the variety deteriorates—"runs out."

There is a tendency always to revert back to the wild prototype. The types of today have been created by applying knowledge and effort to discover the laws of evolution, and use them for our own benefit; in this case, the principle involved is selection, and as soon as we neglect it, reversion commences.

In applying selection to wheat, it is not only necessary to choose large grains, but large heads also. There are not many farmers who are willing to go to all this trouble, although it would undoubtedly pay in the long run. The large kernels for seed may be selected out very easily by screening and this alone would be a great help in keeping the crop up to standard.

CHAPTER XVII

35 Years With Dry Farm Alfalfa

MY first experience with alfalfa was in the British Colony of Natal, South Africa, in 1877. After coming to Colorado I have raised it continuously since 1886—in fact I would not dry farm without it.

Corn fodder has its uses, but in a hard winter with three or four stacks of alfalfa at his back, the small farmer has little to fear; it doesn't blow away and the cattle eat it clean.

In Natal when I was there the weather was dry; they claimed from 20 to 25 inches, but all I could find after summing up for the season was about 15 inches.

Owing to horse sickness, which is a disease more or less sporadic all the time, and supposed to arise from inoculation by a certain kind of fly, everybody used oxen for farm work, some plowing with two, some with four and, of course, the plowing was poor.

There was only one man in the neighborhood who had any alfalfa, and he had only a few rows of it which he obtained by sowing in a seed bed and then planting out.

This piece of lucern, as they call it there, supported a riding horse and two cows, cutting and feeding it green. When one end of the patch was reached the other was up high and ready to cut again. It looked like a mighty good thing, and began to be the talk of the neighborhood; but nobody could obtain a stand of it.

Shallow Plowing Cause of Failure.

The trouble was evidently shallow plowing, so securing the co-operation of one of the neighbors we doubled up ox teams, and plowed a few acres 9 to 10 inches deep. We secured a good stand and it went one-half a ton to the acre the first year; everybody is raising it now.

When I started in on my dry ranch in Colorado I knew just about what to do, and plowed accordingly, some days not plowing more than half or a quarter of an acre, especially when the adobe underneath was tough; but then, what was the difference? I might not have to plow again for twenty years.

As a general rule the alfalfa grew the best on ground plowed in the fall, harrowed and disced in the spring before planting.

Much of my alfalfa was broadcasted by hand and harrowed in. This may seem rather a primitive method in the days of seeders and press drills, but I found that by doing this I was never bothered with a crust; the alfalfa always came through—another thing; when you sow by hand and harrow in, some seed goes in 3 inches, some 2, some 1, which gives you three chances to make a stand, whichever way the rains come.

For instance, in very wet weather that which is down 3 inches and part of that down 2 inches may never come through, but the other half of the seed at or near the surface will all grow, and establish a good stand provided as much as 15 pounds to the acre are planted, for 7½ pounds, if it all grows, is plenty to cover the field. Again, if a fairly good rain comes followed by a dry spell, then the seed at or near the surface is liable to sprout and dry out; but that at 2 or 3 inches under the ground will stay and make a stand.

The Packing Craze.

I am convinced that alfalfa land should never be packed all over after the seed is sown, and very lightly if at all in the seed row. Packing is a craze with some people, just as summer tilling is with others; but if they would deduct just three-quarters of the packing and half of the summer tilling and add all this onto the plowing the results would astonish them.

The best kind of packing is a few months fallowing after plowing, and it costs nothing!

I always planted my alfalfa in the spring for although many claim that late planting is the best, a careful canvas of the situation will disclose that this statement is not borne out by facts. The danger of planting too early is frost, of planting too late, drouth —a storm may come, wet down to the seed which will sprout and dry out before it can take hold.

Hence, common sense says, plant it in the wettest season of the year, which is often at the end of April or beginning of May.

I have known alfalfa in the seed leaf to stand 10° below freezing with 2 inches of snow on the ground, but 2 to 4° of dry frost are sometimes fatal when the sun rises clear.

We must always remember that altitude causes susceptibility to injury by freezing on account of lack of air pressure to counteract the expansive action of frozen sap, which bursts the cells and thus breaks down the structure, or as the farmer says, cooks it, and the farmer is right, for cooking is almost the same process, the breaking down of the cell structure by the expansion of heat or steam, and a burn on a man is very much the same thing as a frost bite; but let us return to our subject.

Bromus With Alfalfa.

Amongst some alfalfa that I planted years ago, came up some bromus inermus; as the gophers worked in the soil and thinned out the stand the bromus spread and filled up the vacant spaces. Thinking this was a pretty good arrangement, the next time I planted lucern I put in some bromus with it. It did not show up the first year and very little of it could be seen in the alfalfa the second year; but as the gophers commenced work, it again began to pre-empt the vacant places, and this particular patch is now nearly all bromus after about fifteen years.

Although on the dry farm where the precipitation is less than 18 inches I would never under any consideration plant a nurse crop with alfalfa, yet I believe it perfectly safe to sow it with bromus. This grass is not in any sense of the word a nurse crop, in fact, the alfalfa is the nurse crop to the bromus, for it seldom shows up much the first year, and if anything suffers for lack of moisture it is not the alfalfa. I have seen oats planted with alfalfa hundreds of times, but it always ended the same way, a crop of oats but no alfalfa; the same when wheat or rye were used. Under dry farm conditions it seems futile to attempt to raise two crops where there is hardly enough moisture for one.

Weeds in Alfalfa.

What about weeds? Well, weeds are another drawback; but it is easier to raise alfalfa and weeds on one patch than to raise alfalfa, oats, and weeds. It is a good idea to mow the young alfalfa about July or August, weeds and all, sometimes this cutting is worth raking, but usually not, and can be left on the ground to dry up. If alfalfa can be held until high enough to cut it is safe from drouth, the tops may dry but it will bud again from the root as soon as the rains appear.

Deep Plowing in Algiers.

The French delegate at one of the Dry Farming Congresses told me that they had great trouble in Algiers in obtaining a stand; but eventually they made out by plowing 20 inches deep. This is the main thing —the whole secret of obtaining a stand—if you can plow deeply it is just as easy as rolling off a log. After the alfalfa is established nothing seems to hurt it except gophers. Those who irrigate, of course, are troubled to some extent with the rot and winter-killing, for anything sappy will winter-kill, and this applies also to dry farm alfalfa on bottoms where the roots go to water. My alfalfa on the hillsides has always wintered perfectly in the driest years, but was sometimes very late in coming out in the spring for want of moisture.

These observations of mine it must be noted were made in Colorado and it is quite possible they may not apply everywhere; local conditions are so different.

Gophers and Black Cats.

The best antidote to gophers is a good hunting strain of cats, and black ones are the best, for the coyotes, as a rule, do not molest them; an old trapper explained this to me by saying they took them for skunks.

I never hesitate to plant alfalfa on sod. There is a prejudice against this, but it comes from those who plow it in ribbons 2 or 3 inches thick. If the sod is broken 8 or 9 inches deep, disced on both sides (before and after plowing) and thoroughly fined down by discing and harrowing alternately, it makes a magnificent seed bed for alfalfa, and in thin sandy soil that blows a much superior one to any old field which is full of weeds and packs easily.

When the roots of young plants get down into the cool moist dirt 10 or 12 inches below the surface they are safe from drouth, and this can be secured in about two months' time if the conditions are made right by deep plowing.

Land Men's Opportunity.

There is no easier way for a land speculator to make money than to hunt up dry lands on bottoms and other places with water at 15, 20 or 30 feet, and plant them to alfalfa. Corn, wheat and other crops may dry out on such lands in dry years, but alfalfa will in a few years get down to the permanently moist stratum just above the water, and yield three immense crops every year without irrigation. Where the water bed is 20 feet it may take three years to do this; where it is 30 feet, four or five years. The most vigorous plants get down first, others follow the next season, and eventually the whole field begins to grow, regardless of the weather.

On the dry farm one of the principal functions of alfalfa is to restore the soil. If any particular field is getting thin, showing signs of depletion, manure it a little and put it into alfalfa before it is too late. If you have a sand bar with moisture at depth, manure it also and do the same.

Once a piece of land is planted to alfalfa, you are through with it, at any rate for the time being, and many unsightly places may be made to yield handsomely with this crop. Some prefer to plant it in rows in order to cultivate it; this is a good way to do; but will the farmer give it any more cultivation than when planted otherwise? Probably not, for all and any alfalfa may be harrowed in the spring before sprouting and once after each cutting, which makes four cultivations to the season.

On old established alfalfa with large crowns some use the disc, but there is no doubt that splitting the crown allows water and bacteria to invade the tuber, favoring rot and other fungoid diseases, but not so much in dry land alfalfa as with the irrigated variety.

What Variety to Sow.

Farmers often ask me what variety of alfalfa to plant. Now to tell the truth I am altogether at sea on this point. All the different experiment stations seem to have their own pet variety; but we hear more talk of the Grimm than any other kind. On my ranch we planted Colorado irrigated seed; paid high prices for Turkestan; planted dry raised seed from Mexico. They all came up, they all did well, they all made hay, they all looked alike to me.

Does it pay to inoculate your land with the nitrifying bacteria? Probably it does in some cases, but there is little if any seed west of the Missouri which is not already infected, and the nodules seem to come on the roots almost as soon as the alfalfa is planted; but if they do not, a little of the top-soil from a neighboring field will accomplish the desired result. The farther we go east out of the lime soils the more necessary it seems to inoculate the land.

This is explained by the hypothesis that in forming nitrates or nitric acid solutions, the bacteria after a while die in their own juice—too much acid—but when there is lime in the soil it uses up this surplus acid by combining with it and forming nitrate of calcium, and the bacterial colonies continue to flourish. For these reasons lime soils are to be preferred for alfalfa.

In these days of baby beef and balanced rations the raiser of alfalfa may be apt to postpone the harvesting of his crop just when the weather is most propitious, in order that the plants may ripen up more, acquiring perhaps an infinitesimal per cent more nitrogen to enhance its feed value; but should he be caught in a heavy rain with his hay down, he may lose 20% of its feeding value in one day.

It is more practical in every way to make hay while the sun shines and not be led away by side issues.

CHAPTER XVIII

Amber Cane, Milo, Kaffir Corn, Broom Corn

ALL of the above belonging to the sorghum family are good drouth resisters, and adapted to the semi-dry area, but possess certain characteristics demanding a corresponding environment. For instance: They all require heat; milo and kaffir more than cane; therefore, the best sorghum for hot days and cool nights, high altitudes and the foothill country, is the amber cane. This to be pure should be black-seeded, the white-seeded being larger and later.

Down in the hot plains, milo is the favorite, the grain being, as a rule, heavier than kaffir, it requires a longer season than cane, but matures more grain.

The land for sorghum should be prepared the same as for corn. The planting may be done with the ordinary corn planter by having small hole plates made on purpose, or by plugging up the holes with lead until the right size is obtained for dropping the right amount of seed.

Sowing usually begins on the plains about June 1st, and may be continued until July, but for grain should be in by June 1st.

Since sorghum seed is planted only about 1 inch deep, it is necessary that the field be as smooth as possible. It may be seeded deeper than this, however, in warm friable soil. The best depth for planting any seed must finally be decided by the farmer himself, for he alone understands the exact soil and climatic conditions in his own neighborhood. The general rule, however, is—plant shallow when there is any danger of rotting from cold weather, from too much crust or too much moisture—plant deep when the conditions are right for quick growth. The amount of seed per acre is usually about 5 to 8 pounds for grain, 10 to 15 for fodder, planted in rows and cultivated in the same way as corn. It is a good crop on sod, having yielded on the writer's ranch as high as three tons dry feed to the acre on new ground broken 8 inches deep.

Broom corn must be planted according to the manner in which it grows on the soil in which it is intended to raise it, for when planted too thinly it may be too coarse, and when seeded too heavily it may prove too fine for broom manufacture; therefore, before going heavily into the raising of this crop, the farmer is advised to try it out. Broom corn has proved immensely profitable where the conditions of growth, market, and labor have been satisfactory.

Amber cane is a first rate cow feed for cream, and by feeding it once a day in conjunction with alfalfa, provides a fairly well balanced ration. After harvesting the cane, the field should not be pastured until frozen and dried brown. The green leaves at the foot of the stalk left by the binder, freeze, ferment, and develop a poisonous volatile acid which evaporates and disappears during the process of drying.

Too much cane fed at the start will sometimes surfeit cattle and put them off their feed; it should be introduced gradually until they become accustomed to it, when a full ration can be fed with impunity.

Sorghum will heat and mold very easily; it is cured in small shocks tied tightly at the top to prevent the rain from piercing the center.

CHAPTER XIX

Rye, Oats, Barley, Emmer, Speltz

RYE is a very valuable dry farm feed crop, it seldom if ever fails, and if harvested at the right time makes a fine grade of hay. Fall rye as a crop is as much superior to spring rye as winter wheat is to spring wheat.

To raise rye for the grain which is usually a profitable crop, the same methods of culture should be used as for winter wheat.

Farmers complain that it never runs as high in yield as wheat. The reason is that they usually give the wheat better treatment.

On summer-fallowed land, fall rye will often go 50 bushels to the acre; on land plowed in August or September, 30 bushels is no unusual crop with deep plowing.

For hay it may be disced in on the corn stubble without plowing; but to do this and expect a payable crop of grain is absurd.

Its value to the dry farmer consists in quantity more than quality, but the feed value is not any lower than that of timothy hay if cut at the proper time. The best time to mow it for hay is about a week after it heads out, then if stacked light and clean without rain damage, every animal on the ranch will eat it clean. By this method all the starch is saved in the hay instead of in the dough, and another cutting may be obtained in a favorable season, for the earlier it is mowed the better chance for a second crop. While the new settler is getting some of his land into alfalfa, he can depend on rye for hay.

It is usually seeded at the rate of 40 to 45 pounds per acre for hay and 30 pounds when grain is wanted;

by trying to raise both at one and the same time the grain is usually shriveled, and the hay tough and wiry, which has given it a bad name with those who have not discovered the proper methods of handling it.

Oats.

This crop is often a failure on the dry farm for the reason that there exists a belief that it can be raised without plowing.

The fact is, oats like flax and some other crops prefer a solid seed bed, and many knowing this think it is a waste of time to plow.

The trouble is, without good deep plowing it is impossible to conserve moisture, for the plowing has more to do with accumulation and conservation than cultivating. There is only one way to secure profitable crops of oats one year with another. This method is to plow deep in the fall 10 or 12 inches at least, and leave it all winter to pack; if it contains 2 or 3 feet of moisture by spring it is safe to plant oats, otherwise not, for if there is only a foot or so of moisture in the ground, and the weather turns dry, it is impossible to make a fair crop.

Seventy-five bushels to the acre may be easily raised on 15 inches precipitation for the season, and probably half that amount in a dry year by the above method. The dry farmer is not advised to attempt to raise oats on 5-inch plowing performed once only in three or four years. A careful canvas of the situation in a country where this is done shows one profitable crop in every three years.

Barley.

The best drouth-resisting barley is the hulless or beardless. It may be cut for hay or harvested for grain. Horses do well on it but chickens prefer wheat. It should be planted in April on fall plowed land.

There are many varieties of barley; their drouth-resisting qualities are about the same as ordinary wheat, but hardly equal to those of the hard Russian, such as the Kubanka and others. Thirty-five pounds to the acre is the amount of seed usually planted.

Emmer.

The best known variety of this grain is the black winter emmer originated by Professor Buffum of Worland, Wyoming.

The methods of culture are about the same as for winter wheat. This crop has yielded as high as 60 bushels to the acre and it is said to be good feed for stock, partaking of the nature of hard wheat.

Spelt. Speltz. Spelz.

The name of this grain is "spelt" in different ways, but they all mean the same thing—emmer is the proper name.

A farmer would say it was a cross between a wheat and a barley, a botanist would probably call it a variety of wheat.

Its feed value is good, for anything that likes it. It is said to yield more heavily than barley, but for some reason since being introduced into this country has not become very popular with the farmers.

It is cultivated in the same manner as barley.

Cultivation of Small Grain.

This is usually done with the harrow until the plants are about a foot high, and after that with the spring tooth weeder, fully explained in the article on wheat.

Seeding.

The usual amount of seed used per acre is from 30 to 40 pounds and it is found that the poorer the soil the more seed is necessary. The depth is from 2 to 3 inches; deep in light soil, shallow in heavy soil.

CHAPTER XX

Dry Land Flax

THIS is a very profitable dry farm crop wherever the conditions are right, and the seasons favorable. It is more suited to the cooler states than the hot plains, and is found growing wild in the foothills, but not very far south.

There are wild perennial varieties which come up from the root every year like alfalfa, but the seed is too small to be valuable. It is quite likely, however, that a perennial variety may be evolved by crossing, which will prove of value, and from which a crop may be harvested every year without replanting. The wild varieties do not seem to be afflicted with the blight or wilt to the same extent as the types under cultivation.

Flax does best on a deep, well settled seed bed. To plow deep in the spring and then plant immediately is wasted effort as far as flax is concerned.

The ground should be plowed deep in the fall or at least disced at that time, and plowed early in the spring, and thoroughly disced and harrowed alternately until the bottom (lower half of the seed bed) is quite solid.

Because flax prefers a compact seed bed is no reason for shallow plowing. It is this style of surface farming which accounts for so many ridiculously low yields, for with proper tillage it may be made a heavy yielding, profitable crop. It is a good drouth resister where the rays of the sun are not too hot, which seem to have a greater effect on it than scarcity of moisture; for this reason it is better to drill it in north and south rather than east and west. Flax will grow on any ordinary sandy loam soil, and the right physical condition of the ground seems to be of more importance than high fertility. It is often said that it is hard on the soil, but this idea is hardly borne out by facts, except that by means of its root ramifications which are exceedingly close, it uses up more moisture, more soil solution than some other crops; at the same time it will mature seed with less moisture actually in the soil than any small grain crop.

Flax has its own diseases as every crop has; but by disinfecting the seed with formaldehyde and rotating, they can be easily avoided. The principal of these is blight or wilt, and it usually occurs after glaring hot spells with an insufficiency of moisture. Whether the spores of this disease gain an entrance through a scalded portion of the stem or leaves or effect a lodgment through the root is not as yet known; but it is known that the infection remains in the ground, and nothing will kill it out except planting another crop upon which the fungi cannot thrive—starving them to death.

The amount of seed planted to the acre is usually about 25 to 30 pounds.

The only source of profit from flax at present is the seed for oil and oil cake; but the time will come, and it is to be hoped in the near future, when the fibre also will be purchased for the manufacture of linen, and there is no question but that a marketable grade can be raised upon which a large industry could be built up. Some of our empire builders should take this matter up.

CHAPTER XXI

Potatoes on the Dry Farm

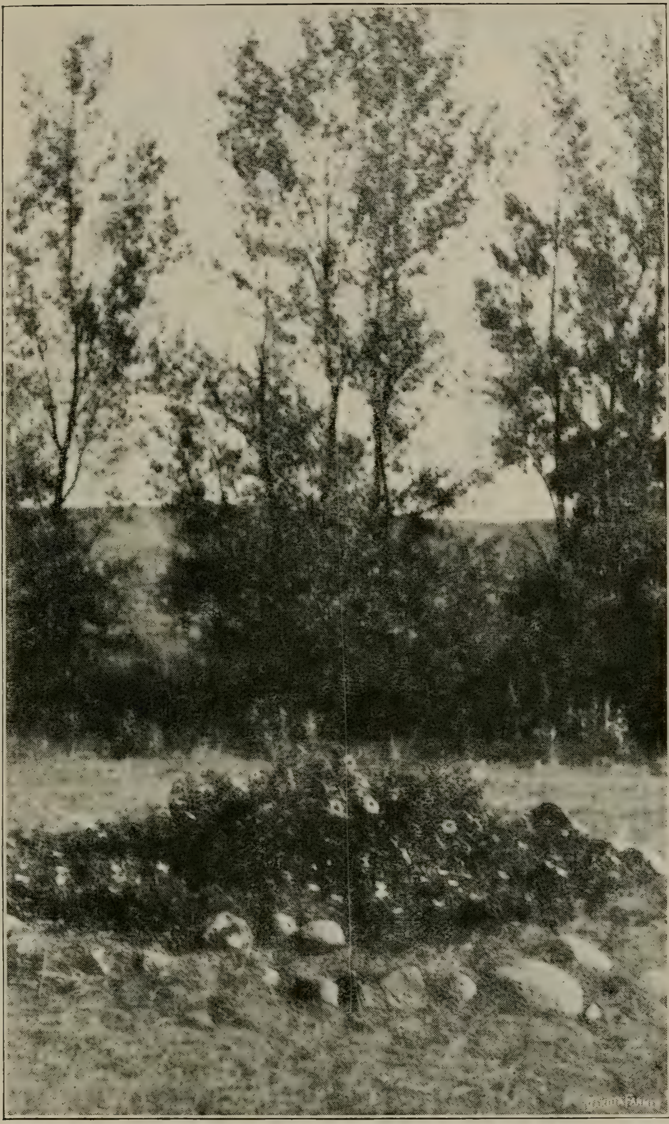
THIS crop may be raised in some soils and not at all in others. As to what constitutes a potato soil is an agricultural conundrum which has never been solved. It is known, however, that potash, and phosphorus are essential, for in every potato belt a fair amount of these minerals is always present in the soil.

Therefore, if the dry farmer happens to be in a good potato belt, there is nothing to prevent him from raising them provided he is willing to do the work, but unless there is a goodly amount of moisture in the ground, and the season looks favorable, he had better plant some other crop which requires less moisture.

The secret of raising a big crop is a deep, well worked seed bed in the best of tilth, neither too loose nor too compact. The texture must be finely grained and even (homogeneous) throughout without lumps or clods. Therefore the most friable soil on the farm, if rich enough, should be chosen for this purpose.

Some large crops of potatoes have been made by planting on summer-fallowed land, but if this is not done the land should be plowed in the fall, and winter-fallowed in the rough to catch the snow. In the spring the field should, if possible, be cross plowed, and harrowed and disced alternately until the surface is fine and mellow. It is impossible to plow too deeply for potatoes; in the island of Jersey they are now plowing 20 inches deep, fertilizing with kelp (sea-weed) and raising 600 bushels to the acre.

The potatoes should not be planted over 4 inches deep, for they need the surface warmth, and will root



Dry Farm Flower Bed and Silver Poplars, E. R. Parson's Farm.

and sprout with greater vigor than when planted deeper.

The time of planting must depend on local conditions, and like many other things must be tried out by the farmer himself and his neighbors, some favoring April planting, some May and some June.

The best results are obtained by planting a piece of choice potato containing one eye in each hill, which should be 2 feet apart in the row, with rows 3 feet apart.

If the weather turns dry the hills should be thinned down to one sprout each; but with plenty of moisture in the ground more may be left.

It should always be kept in mind that the success of a potato crop depends on rich friable soil, deep plowing, and constant cultivation. Therefore, as soon as the sprouts appear the harrow should be started; very few will be torn out by this implement if properly slanted, but if necessary the teeth which strike the row may be removed. When the plants are too high for the harrow, the corn cultivator is used, and intertillage may be profitably performed until after the blossoming period, but the potatoes should not be hilled up, as they are in the humid states.

Fairly level cultivation is the best, and if there are 2 or 3 feet of moisture in the soil when the crop is planted the chances of obtaining a large crop are excellent in a district where the soil is right.

In order to raise crops one year with another, heavy manuring and rotation with some grain crop or alfalfa should be practiced. In soil which is not over rich, good crops may often be secured for a year or two by planting on newly plowed sod. The sod should be disced in wet weather and the surface thoroughly disintegrated before plowing, which should be 8 or 9 inches deep or deeper if possible, and the field must be worked up into a fine tilth by alternate discing and harrowing before the potatoes are planted.

The work should be done in the fall and some moisture conserved before planting, for the chances of a crop on spring plowing are very poor, unless there happens to be an unusually heavy rainfall. Even when the land is plowed in the fall another plowing in the spring is very beneficial, but if this is not given, a good deep discing will help the seed bed.

It is impossible to say how any particular potato will do in any given neighborhood until the matter is tested out; but in the central dry farming states the following varieties are used by the successful growers and have a good chance of doing well anywhere. Early Rose, Petoskey, Early Ohio, Irish Cobbler, Peachblow, and Early Six Weeks; besides these, of course, are many varieties known locally.

The Early Six Weeks may be planted in states of the latitude of Colorado, Kansas, etc., as early as April 10th and will often make potatoes for the family by the middle of July.

The tubers of potatoes are subject to scab and the foliage to blight, but these troubles may be almost entirely prevented by disinfecting the seed and by rotation.

Sometimes the crop seems to be helped by pruning off some of the tops or the blossoms, but nothing definite has resulted when this idea has been put to the test.

By the methods outlined above a yield of 250 bushels to the acre has been obtained in a favorable season.

CHAPTER XXII

Beans, Peanuts, Millet, Peas

BOTH Mexican and Navy beans are good dry farm crops, and will yield heavily on conserved moisture. Fall plowed land worked over in the spring is better than spring plowed; but if the latter is used it should be plowed 10 or 12 inches deep in March, and disced and harrowed alternately until thoroughly fine and mellow, the last working being performed just before planting after all danger from frost is over.

The Mexican bean is a little the best yielder as a rule, but the Navy brings the most in the market. Both of these are row crops and should be cultivated by the same rules as corn. They must not be planted near a prairie dog town, for these rodents, and also rabbits, feed on the leaves.

Planted in rows 3 feet apart and a single plant every 6 or 8 inches is the right method to secure a good yield. A specially constructed plate is used in the corn planter for this work, and may also be tried for peanuts, although some claim that planting by hand or with the hand planter is best for the latter.

Beans should be planted about 2 inches deep and 25 pounds will plant an acre.

One of the best methods of harvesting this crop is to attach a canvas to the sickle-bar of the mower, allowing it to trail, and hold the beans as they are cut to prevent loss by shattering.

Peanuts may be raised in the hot plains country of southern Colorado, New Mexico, and other states. Peanuts and milo are found in the same districts, and grow under the same climatic conditions. The Spanish peanut (really a Mexican adaptation) is the best variety to grow and the most drouth-resistant.

It is difficult to harvest as in digging or lifting the nuts often break off, and are left in the ground. The problem, however, of harvesting is easily overcome by pasturing to hogs and cattle; the former get the nuts, the latter the tops. They are sometimes lifted vine and all by loosening the rows with a plow minus the moldboard.

In their proper environment they will mature in 90 days. When the growth is good they may be mowed for hay, the tops being almost an equivalent for alfalfa, and sometimes running as high as three-fourths of a ton to the acre.

Hogs turned into a peanut pasture should gain at the rate of 1,000 pounds for every acre.

The growth of the peanut is retarded only by long drouth, but as soon as moisture falls, fresh sprouts are developed, and the plant takes on a new lease of life, usually maturing a crop.

This characteristic places it in the ranks with the sorghums and other great drouth resisters; it is invaluable in the warmer dry farming states.

Millet.

Millet makes a very rich hay which must be fed sparingly. The German is the favorite variety. It is a good catch crop when other crops have failed, and may be planted as late as July 1st. It is not exactly a sure crop, for it is easily injured by hail when first sprouting.

It may be cut and cured for hay just as the grain is ripening. Chickens will eat millet, but not in preference to wheat.

It should be seeded about 20 pounds to the acre, and dragged in lightly with a slanted harrow, on a fine smooth seed bed.

Peas.

The Canada pea and other field peas must not be confused with the cow-pea, which is of the nature of a bean and will not stand light frosts. The former prefer cool climates, cannot grow in extreme heat, and sun-burn easily on light colored soils; but are valuable in the northern states, do well in late cool seasons, and may be planted early.

The cow-pea is at home in the warmer or more central dry farming states and may be planted from May to July as it will mature under the right conditions in about 80 days. All peas are deep-rooted and do the best in deep plowed or subsoiled land. They may be drilled in at the rate of 80 to 90 pounds to the acre. The tops are good feed for stock, and they are usually harvested by mowing and cocking in the field; hogs or sheep being turned in to clean up.

The most profitable method, however, with crops of this kind is to pasture them off on the ground, and then plow them under in the shape of manure.

CHAPTER XXIII

Vines, Root Crops, Sugar Beets

ON many dry farms, especially those on gulches, there is often to be found an odd corner facing north with good sandy soil, and some leaf mold. This is just the place for vine crops.

Pumpkins and Squashes.

Pumpkins and squashes prefer some shade, and for that reason are often planted with corn; but if this is done on the dry farm, they should be put in only where there are vacant hills. Thus when there happens to be a poor stand of corn it may often to advantage be filled up with vines of pumpkins and squashes. When these crops are planted alone in the field the land should be plowed very deeply and laid off in lands, leaving a dead furrow every 8 feet. These dead furrows should then be worked up and down with the plow, and about half filled with the top soil before being planted.

The seed should be dropped in hills about 5 or 6 feet apart. About 2 to 3 pounds of pumpkin seed will plant an acre.

Mice, prairie dogs and gophers are very fond of these seeds, and will get nearly all of them unless treated with some ill flavored material.

Watermelons and Cucumbers.

Watermelons and cucumbers belong in the garden, but may be raised in sandy loam by the above method if the soil is rich enough.

Turnips.

The best root crops on the dry farm after potatoes is turnips. Late planting sometime in July usually gives the best results, and the strap leaf varieties seem to be the best adapted to dry land conditions. The turnip fly, which eats holes in the leaves, hatches out in the early spring, but begins to disappear in June.

Land for this crop may be plowed early, and clean fallowed until planting time; the surface should be fine, and the seed dragged in or drilled about half an inch deep. If the seed is good, 6 pounds to the acre will be plenty.

When the stand is too thick it may be thinned by harrowing. If desired this crop may be planted in rows and cultivated.

Rutabagas, Carrots, Mangel Wurzels.

The culture of rutabagas is the same as that of turnips. Carrots may be raised in the field but are difficult to weed; they should be planted in rows about 2 feet apart, and cultivated with a one-horse garden cultivator; early planting is the best. Mangel Wurzels for cattle belong to the beet tribe and are raised by the same methods as sugar beets.

Sugar Beets.

Sugar beets may be profitable raised by dry farming methods and may be made to yield ten tons to the acre in favorable years. No farmer, however, is advised to go into this line of agriculture unless he is prepared to do the work as outlined below.

The land should be rich and mellow, besides being thoroughly prepared as is recommended for potatoes. The beet needs a deep, friable, homogeneous seed bed. When the ground is plowed 4 or 5 inches the beet will be the same length; therefore, to obtain a 10- or 12-inch beet, 10- or 12-inch plowing must be done.

It is a waste of time and seed to plant beets in dry ground, and although some pretty fair specimens have been raised on the winter-fallow, the only safe method which it is possible to recommend is the alternate fallow system.

By fallowing a field one year and planting it the next, the weeds are nearly all killed out and half the expense of raising beets (the hand weeding) is avoided.

The unirrigated beet is not as large as the irrigated, but contains more sugar, and there is little doubt but that it would bring more at the factory. They should be planted in rows about 30 inches apart and thinned down until they are a foot apart in the row. Deep plowing and intensive cultivation make the crop.

About 6 pounds of seed to the acre is usually planted after danger from frost is over. The land, if fallowed a whole season, should be disced as deeply as possible and thoroughly pulverized before planting. A second plowing in the spring not necessarily as deep as the first is even better than a discing. For sowing, the press drill is the best implement now in use.

Note.

Although the writer has given directions for the raising of a variety of crops, he believes that the best procedure for the beginner is to go slow, commencing with standard dry farming crops; such as corn, sorghum, rye, winter wheat and alfalfa—all good drouth resisters, gradually working into other crops as he finds it profitable or not, always remembering that feed crops for stock need not necessarily fully mature or attain the standard of excellence demanded by buyers of grain, and that while some past masters in the art of dry farming have raised everything under the sun and made fortunes out of small grain, it is usually much safer, and, in a general way, more profitable on account of transportation and market conditions to convert the farm crops into such staple articles as beef, mutton, pork, poultry, eggs, butter, etc., and ship them in concentrated form.

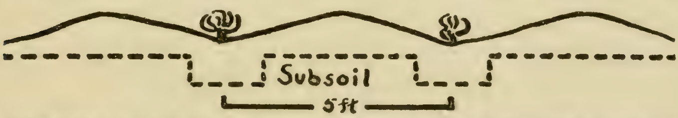
CHAPTER XXIV

The Dry Farm Garden

THE correct principle in this domestic branch of dry farming is: To provide moisture for the rows of vegetables in the dry farm garden by drainage from the adjoining soil surfaces. We all know how easy it is even on the dry farm to raise flowers, plants, creepers, etc., in little beds around the house and under the drip from the roof; this drainage from the roof provides precipitation from a larger area than the plant could otherwise receive, hence it gets more than its share—more than its share would be in the field.

This is the principle we apply to the garden; for a few feet of space more or less make little difference, and more space means more moisture, especially when we show how all the water which falls on this space can be drained directly to the roots of the plants.

The land for the garden should be plowed as deeply as possible in strips 5 feet wide which will leave a dead-furrow every 5 feet, and a ridge or back-furrow



Plan of the Dry Farm Garden Showing How the Dead-Furrows are Plowed Out to Give Root Depth at A and B, for the Vegetable Rows.

between every two dead-furrows, in other words, alternate hollows and ridges.

The rows of vegetables are, of course, in the hollows and get the run-off or drainage from the ridges which gives them about three times as much water as the crops in the field receive.

Before planting, however, the dead-furrows should be given an extra plowing to allow plenty of depth for rooting, and some leaf mold or corral humus mixed in with the soil.

For the garden there is nothing like leaf mold if you can get it, but failing that, the next best thing is humus from some old cattle or sheep corral.

It will pay well to haul a few loads of leaf mold and distribute it up and down the dead-furrows before plowing under.

It may seem a good deal of work, but one good fertilizing will last for several years and green peas, fresh beans, cabbages, carrots, turnips, beets, asparagus, etc., with nearly every meal are surely worth while.

The site for the garden should be selected where the soil is rich and deep; but where there is no choice, near the house is always the handiest. Some enterprising folks will often pack water to their garden, but this should never be done early in the season because it encourages the plants to root too near the surface, and then when warm weather comes they can with difficulty be prevented from wilting; therefore if plants are watered at all, they should be watered only as a last resort at or near maturing time. To water by hand hills of melons, squashes and cucumbers, even tomatoes, there is nothing handier than a quart can with some holes in the bottom sunk in each hill. The water is poured into the can and leaks slowly into the ground and sub-irrigates the plant without any waste.

The garden should be kept well cultivated or hoed and no crusts allowed to form, and if all these details are properly attended to will prove a material addition to the resources of the farm.

In planting in the row, plenty of space also is necessary; a good rule being to give everything twice as much room as usual.

Cabbage planted 2 feet apart in the row and the rows 5 feet apart have 2x5=10 square feet to exploit for moisture; with a precipitation of 12 inches, 10 square feet will receive 625 pounds of water; now we can raise a very good cabbage on 300 pounds, and a fine cauliflower on 400 pounds, so that if the precipitation is conserved in the soil the year around we can allow nearly half for waste by evaporation and then raise a fine garden.

Asparagus and pie plant do particularly well without irrigation, while peas, lettuce and radishes should be planted as early as possible to avoid the heat. Beans always do well, also melons, cucumbers and squashes when deep rooted, otherwise they will wilt easily and become stunted.

The lettuce bed should be shaded in summer with a board or two. Strawberries should be planted 2 feet apart in the row and no runners allowed.

Turnips should be planted late to avoid the little hoppers which eat the leaves; ashes, however, will help to keep them away, also on the radish bed.

Some of the best flowers are, holly-hocks, petunias, portulaca, nasturtiums, phlox, and poppies. The best climber is the Virginia Creeper, in the seed books it is listed as Ampelopsis quinquefolia.

CHAPTER XXV

Dry Farm Horticulture

THERE is nothing easier in dry farming than raising trees. They discovered this in California half a century ago and the dry farm fruit product consisting of olives, walnuts, wine grapes, prunes, peaches, apricots, etc., raised on less than 17 inches of precipitation without irrigation runs into the millions.

Why are trees easy to grow? Because as I have always pointed out, successful dry farming is a matter of depth.

We can plant a seed 2 or 3 inches deep; but we can plant a tree 2 feet deep in a subsoil 17% wet, containing enough moisture when properly mulched to carry the tree a whole season without a single drop of rain. How much of this 17% moist soil is needed to do this? Not less than 2 feet, more if possible.

How do we get this? We can make sure of it by planning a year ahead, by plowing and fallowing until the requisite moisture is secured.

Nature may provide it during the winter months whether we fallow or not, and if she does so, it is quite safe to plant trees in the spring.

Water Required By Apple Tree.

A 15-year-old apple tree, I find on my ranch, does very well with about 60 tons of water, making several boxes of good sized apples. How do we get this 60 tons of water for each tree?

We plant the trees 40 feet apart which gives each tree 1,600 square feet; with a precipitation of 14 to 15 inches such as I farm on, you will find if you figure it up that 60 tons of water approximately fall on this square of 40x40.

Cherries and plums will do with much less; the allowance for them is 20x20; small fruits 10x10. Why does a tree use so much water?

Because the soil solution carries only one part of solid matter in several thousand of water and to secure this mineral matter the tree takes up the solution, transpires the water through the leaves into the atmosphere and hangs on to the mineral matter.

Loss From Transpiration.

How much of this water can a tree transpire in a day? A 20-year apple tree during a warm summer's day may transpire from 15 to 30 gallons. How about other vegetation? Everything does so more or less according to their leaf structure. Does this transpiration affect the climate? It certainly has a local effect; the settled districts of the west show a higher atmospheric humidity than they did years ago.

Will this increase the rainfall? We do not know; the Meteorological Department has not existed long enough to provide the adequate data.

We do know, however, that hygroscopic moisture is just as valuable to the dry farmer as rainfall, for it cuts down the evaporation, which saves moisture.

How to Plant Trees.

In planting trees 40 feet apart, we would prepare the ground by plowing lands 40 feet wide, planting the trees in the dead-furrow. This saves a whole lot of digging, for if the plow gets down 8 or 10 inches deep the holes need be dug only about another 15 inches, and about 2 feet wide. When planting 20 feet apart the lands, of course, must be 20 feet wide and so on. The best way is to plow and fallow during the spring and summer months and dig the holes in the fall giving them a chance to fill up with snow and slush.

This dead-furrow method is also a help to the young trees because it leaves the ground dished towards them, throwing all the run-off right to their roots.

In order to handle trees just right, which they seldom do in the nurseries, it is necessary to understand something about their anatomy. The most delicate part of a tree is the root; this has no bark to protect it; it is designed to exist in a moist cool environment, heat and sunlight destroy it.

Damage Done by Poor Handling.

Ten minutes in the sun will reduce its vitality by one-third, one hour will cause the tree to hang fire after planting out, and not leaf out perhaps for months until all damage is repaired; one day in the sun will destroy almost any tree.

Buy from a nursery which has proved up, as per testimony from the neighbors, not from one which sells trees dead or alive or dying.

Trees should be packed in paper-lined boxes and the roots kept moist; as soon as they arrive they should be taken out and buried in moist soil up to the branches in order to plump up and recuperate. They should be well sprinkled and kept damp until needed to plant; a week or two of this will not hurt them. In taking them out to plant, the roots should be covered with wet sacks. Here we come to the two most important rules in tree planting.

They are: Cut back three-fourths of the top, and tamp the roots solid. Unless you make a good earth connection between the tree and mother earth, you might as well throw it away.

An Old Fallacy.

"Shall I put anything besides earth in the hole?" you say. Not on your life. We know what grandfather did: He put old bones, or steer's heads or dead cats and manure in the holes and had the finest trees in the whole country side. This was all right for him because he lived in a wet country; but we dare not do this. In the first place it is not necessary, and in the second place this rubbish makes air spaces, and these air spaces are deadly to have around the roots of a tree when moisture is scarce. We want a solid firm contact between the root and the fine, soft, moist earth, nothing more and nothing less.

The orchard may be manured later on by discing it in on the surface when necessary.

When the trees are big the leaves should be cultivated under in the fall for humus and not be allowed to blow off.

Any Good Land is Fruit Land.

We hear a lot of talk among real estate men about fruit land; but the sum total of it is usually that the land is good for fruit because they have it to sell.

Any good land which will raise grain or corn will raise fruit if the subsoil is right. Sandy soil is fit for orchards only when it is deep and rich right through to a good depth, but clay loam is almost always safe to plant on unless it runs into joint clay or other barren stuff at two or three feet.

There are many places in California where the top soil was used up by planting it to small grain from 30 or 40 years, which is producing fine crops of grapes, prunes, plums, peaches, etc., from the subsoil, which happened to be composed of different strata of good wash dirt.

As far as exposure is concerned some prefer an east or south or southeast and some a north exposure, and as to which is the best is usually determined by the spring weather which is different every season. In planting on river bottoms it is very necessary to ascertain how deep it is to water, for fruit trees are upland by nature and a water-logged condition of the soil will kill them; for this reason I would not care to plant them with water any closer than 10 feet.

Apples will stand more water than cherries or plums, but too much favors winter-killing in any fruit tree. As in all dry farming we must cultivate the orchard with an eye to accumulation as well as conservation; we must allow no run-off. I find in my own orchard that enough cultivation to keep the weeds out, namely about 12 times during the season, will conserve about all the moisture that can be conserved.

Cultivation.

Ten or twelve cultivations will also keep all the crusts broken and the surface perfectly loose. For accumulation purposes the work should be as rough as possible, about three inches deep and well furrowed.

A good plowing once a year especially in the fall is recommended; cutting the surface roots does not seem to injure or hurt the trees in any way. In California all the orchards both dry and irrigated are plowed at least once a year, usually over 8 inches deep.

In my orchard the trees were planted about 6 inches deeper than they were in the nursery, which leaves plenty of room above the roots for either plow or cultivator. When trees are planted on a side hill, something more than ordinary cultivation is needed to prevent run-off. This is accomplished with the disc, and the reversible disc is the best; for, with this implement, the rows can be hollowed out to catch the water or filled again whenever the owner desires. When the disc is run once or twice in the same row it makes what we might term a hollow terrace across the slope which hold water perfectly. When the row between trees becomes too deep it can be partially or entirely filled by reversing the disc.

These rows which cross a slope should be run as level as possible to discourage run-off, and the cultivation when done both ways should be done across last, so as to leave everything in shape to catch a heavy rainfall.

Locust Trees on Dry Farm of E. R. Parsons, Eastern Colorado.

When to Cultivate.

I am often asked if there is any object in cultivating when the mulch has not been crusted by rain since the last cultivation. I do not believe there is, although in some of the Pacific states where the humidity is high and some distillation from the subsoil during the cool nights, we find sometimes the mulch settling and breaking to some extent without any rain.

There is no question whatever but that dry raised trees properly attended to obtain all the water they require under a precipitation of some 14 or 15 inches and from my own observations on this point feel confident I could raise upland trees on a precipitation of 8 inches.

Opportunity to Store Soil Water.

We have already shown that by giving our largest trees, the apples, a square of 40 feet (planting them 40 feet apart each way) we are allowing them about 60 tons of water per annum when the precipitation is about 15 inches; but the young apple tree does not need, when first planted, more than a few hundred pounds per annum—then what becomes of the other 59 tons and over? That part of it which is not evaporated in transit goes into the ground and we conserve it for future use; therefore we soon discover we are gaining moisture at the rate of several feet a year, and it is not uncommon to find that after the sixth year, we have 10 to 15 feet which will render any tree absolutely drouth proof for several seasons whether it rains or not.

It was the discovery of these facts that led me to plant a commercial orchard in 1894, and as I have explained before, you may have 100 feet of dry subsoil under your moisture, but it cannot steal it notwithstanding all the nonsense they talk about capillarity. As the trees get older they use more moisture, so it is good philosophy to save all we can and plant nothing between the rows to use it up, for when our apple trees arrive at the age of 15 to 20, the precipitation about balances the transpiration and the trees are just about enabled to hold their own and produce good sized fruit.

Treatment of Old Orchards.

Now here comes a question. Supposing we find at some future time that the trees have grown very large and the fruit is becoming small as well as the leaves, which are indications of not enough moisture, what can we do about it? We can reduce the transpiration by trimming back the trees, thinning out the branches, or we could cut out every other tree. We can also help the situation by fertilizing, making the soil solution stronger so that the tree can get along with less water. As the trees increase in size they create large snowdrifts in the orchard and after a blizzard it is nothing unusual to imagine that all the snow on the ranch has piled into it; this is a big help in moisture accumulation.

In winter the trees must always be protected from rabbits until they are 3 or 4 years old. We buy a bolt of wire mosquito screen, 2 or 3 feet wide and cut strips 6 inches by 2 feet or by 3 feet if the trees are tall enough, then we roll these strips (on a table) round a broom handle which gives them the right shape to snap around the tree.

Use Varieties Adapted to Your Latitude.

What varieties of trees or fruit are the best to plant? This is a question that must be decided locally by the experience of those who have already raised fruit in your particular locality and at your altitude; whether they have done so by irrigation cuts no figure, for irrigation is rather a handicap to trees, especially in the matter of winter-killing. There is one point, however, and this is, I believe it best always to choose large fruiting, vigorous growing varieties. As far as hardiness is concerned the dry farm orchard has the advantage. Thousands of irrigated trees are killed every winter by ill advised watering. A warm spell comes, the sap cells on the south side of the tree become gorged with liquid, a storm comes down from the north, a solid freeze; snap goes the bark.

Cause of Winter-Killing.

We cannot expect the sap cells of a tree to hold frozen water any better than an iron pipe which will burst every time; altitude increases the bursting power of the frozen sap in the same way that it increases the bursting power of the arterial pressure in man which may cause his nose and ears to bleed at high altitudes; therefore we find that a tree which will stand 40 below zero at the coast may winter-kill at 20 below at 4,000, and at 10 below at 6,000 feet altitude.

It is well to bear this in mind when we want to send back east or to the old country for some trees of those fine apples we used to eat when we were boys.

Trees will winter in land almost dry which contains only 2 or 3% above the hygroscopic equivalent. I know, because I have done it for experiment. I have also wintered trees in cellars with a little dry dirt thrown over the roots.

My wife has wintered geraniums by cutting them back, taking them out of the ground, tying them in bunches and hanging them on a 2x4 in the cellar. It is all nonsense to say trees need ditch water in winter.

Drouth Does Not Kill Trees.

When the trees dry out after the winter it is not for want of water; it is because the sap cells are ruptured; the protoplasm is dead, the sap cannot rise. It is very difficult almost impossible for drouth to kill a tree of any size because not only are the roots away down in the subsoil, perhaps as far as the top of the tree is above ground, but the whole heart-wood of a tree is a reservoir for the sap cells to draw upon in time of need. The sap circulates through the sap wood and cambium layers adjoining the bark, making the whole circuit of the tree from root to leaves and leaves back to root. The tree grows by successive layers forming each year on the outside next the bark; thus the outside layers are gradually covered up and becoming inside wood, eventually heart-wood; as this process goes on the inside layers gradually lose their protoplasm and become virtually dead, taking no part in the raising of the sap or the life of the tree; but these empty wood cells of which the heart-wood is composed are fine receptacles for surplus sap and during the wet spring weather when there is a surplus of this material the overflow finds its way into them and stays there until needed. Thus we find that all trees are good drouth resisters excepting, of course, bottom land trees which have become adapted to their environment. The same rules which apply to orchard trees also apply to shade trees; there will be no trouble with them if planted in rows and cultivated.

CHAPTER XXVI

Forestry in the Arid Regions

IT is estimated that in a very few years our forests will become depleted, our lumber supply almost used up, unless some policy of conservation is inaugurated which will save the day.

The Forestry Department are doing their best, but what can planting every year a few acres of forest trees amount to when thousands of square miles are burned off every season?

How is this problem solved in other countries?

One of the greatest countries of the old world for conservation of soil, trees, everything, is Germany. Conservation is taught in the schools, everybody understands it; the man who burns a forest is just as much a criminal as the man who burns a village; the man who cuts a sapling to make a 2x4, which in a few years might grow into a hundred feet of lumber, is just as much a robber as the man who robs a bank.

There they have laws which have popular sentiment at the back of them. Here we have laws which are difficult to enforce because popular sentiment has never been educated up to them.

Campaign of Education Necessary.

The only way we can change this is by a campaign of education. If the forest fires can be prevented, the rest is comparatively easy; but can we prevent them, and then reforest the denuded areas?

It is a big contract, but what other countries have done, we can do.

The forests belong to the nation; if they are of value they should be conserved and not despoiled by the lumbermen, the miner and by overstocking with cattle.

In some of the provinces of Austria and Germany, a law exists that every man who cuts down a tree must plant another, and many of the great lumber companies own their own nurseries.

The question which concerns us, however, is this: Have we as farmers any particular interest in the conservation of the national forests?

We certainly have, and for many reasons. Trees help vegetation because they create a moist atmosphere.

Transpiration of Trees.

A large Engelmann spruce, for instance, may transpire from 300 to 500 gallons of water a day. An ordinary sized tree from 50 to 100 gallons. In many cases this water comes from great depths from which nothing but the roots of a giant tree would ever raise it; therefore we may justly consider a forest of trees as an aggregation of pumps, pumping millions of gallons of water into the atmosphere from the lower depths of the soil. When we appreciate this fact, we do not have to strain our imaginations very much to perceive that a good sized forest may raise enough water every twenty-four hours to supply a fair-sized cloudburst.

Now we do not wish to take part in the dispute as to whether vegetation causes more rainfall or not; but it assuredly is a fact that this water falls some time, somewhere; but supposing it were possible for it all to stay in the atmosphere, even then, nothing could be better for the farmer.

It has been shown by Dr. Alway, Hilgard and others that under damp atmospheric conditions crops can live and grow in soil containing only 3 or 4% of moisture, but under dry atmospheric conditions 6 or 7% is the limit. No man can doubt the fact that a range of mountains covered with forests to the west of us from which our winds blow is a moisture producing area of incalculable value to the man who raises crops.

Someone might remark, "This old state is pretty dry anyway." Maybe it is but I have seen others a good deal drier, especially farther south where there are no trees to the westward. Lakes, reservoirs, irrigating projects and agriculture in general all afford moisture, and for this reason there is little doubt that settling a country improves conditions.

Atmospheric Moisture Important.

Millions of tons of water which years ago ran off into the gulches, from thence into the rivers and down to the sea, are now caught in the deep plowed land and transpired by the crops back into the atmosphere again, creating produce during the process.

Years ago when I first came to Colorado, we rarely saw any dew there, but of late years in my neighborhood the dews have been so heavy as to seriously interfere with the haying. It is open to argument as to whether all this moisture from different sources really increases the rainfall. It would seem that it ought to, that a local shower for instance, taking place where the humidity is high, would naturally precipitate more moisture than where it is low; but it could hardly affect the large cyclonic storms which at times sweep the continent.

In order to arrive at anything conclusive on this point it would be necessary to compare the records for fifty or a hundred years, for meteorological conditions are the most inconstant thing on earth and a 10 or 20-year average tells us little or nothing.

Railroads Engage in Forestry.

Foreseeing that the timber supply is likely to fall short in the future, many of the railroad companies are forestalling this condition by planting trees, especially the Catalpa for ties. These plantations are not actually in the dry farm country, but very near it, some of them doing well where the precipitation is not much over twenty. It is expected that in course of time the trees will become large enough to shade the ground, prevent weed growth, catch plenty of snow and thus establish forest conditions; take care of themselves in fact.

Can we do this in the dry country? Probably not on much less precipitation than 20 or 25, for we have to give the trees so much room on account of moisture conditions that it will be hardly possible to obtain both the shade and the moisture sufficient for the needs of the tree. Nevertheless, I believe there are many waste places which seem as if designed by nature for this very thing. In the mountains among the rocks and gravel where weeds and grass can hardly grow, trees once established hold their own and grow right along; the reason being that a tree root being perennial gains something in size and reach every year, becoming stronger and more efficient, a slow but sure process which enables it to obtain everything in the way of sustenance that can be obtained in such an environment, and in some cases to extend its roots into good soil below the rocks entirely out of the reach of other vegetation.

Waste Land Good For Trees.

Therefore, wherever we can find rocky gravelly hills, there is a very good chance even on the plains of establishing forest conditions with certain trees, especially of the conifers, the varieties of which we will give later on.

In a previous article I have already shown that we can accept it as an absolute fact that in proper soil with the requisite plowing and cultivation we can grow any upland trees which will not winter-kill anywhere on our prairies where the winds are not too severe. Reforesting the mountains with the varieties which belong in that, their own natural environment, should be a comparatively easy task.

All dry farm work depends on the accumulation and conservation of moisture, so must what we might term dry forestry.

On the mountain slopes which are not too steep we prefer the terrace method, which consists in running hollow terraces across the slope about 50 or 60 feet apart to catch the precipitation as it comes down the mountain side. These terraces are made with plows and road graders a few feet wide and hollow toward the center to hold the water, and the trees planted well towards the inside.

To conserve the moisture after it is caught, rocks, boulders, rotten wood, pine needles, or in fact any foliage which happens to be handy can be used as a mulch and no further attention is necessary. The advantage of this method is obvious, if the terraces are say 60 or 70 feet apart, then each tree gets the drainage of 60 or 70 feet of slope; this is plenty to keep it going, and once established the trees easily hold their own in their natural environment.

Where the slopes are too steep for terracing, each tree can be hand planted at the apex of a v-shaped embankment which will catch more or less run-off according to its size.

Forest Tree Seedlings.

In humid countries some areas where the conditions are favorable are sometimes reforested by seeding; but the seeds of conifers have many peculiarities with regard to germination which are hard to overcome even under nursery conditions, and this method is therefore hardly feasible for general practice in the arid zone.

Therefore we find ourselves limited to the planting of either nursery trees or forest seedlings.

Which are the best?

The Germans as usual are the greatest adepts in this line of work and find no difficulty in raising all our mountain evergreens from seed by the hundreds of thousand.

In Erfurt, Germany, we can buy all we want of our young forest trees, raised from seed, for a dollar or two a hundred. They send men to the Rocky Mountains every year to gather these seeds which they ship back to their nurseries and there propagate them.

Our eastern nurserymen buy the little trees about 5 inches long every spring by the thousand, claiming that they can purchase them cheaper than they can raise them.

I tried out a lot of these trees one year and found they needed plenty of moisture and shade in order to establish them, and were not at all suitable for mountain work.

This leaves us nothing but the forest seedlings for reforesting and this is the true solution of the problem as far as the arid zone is concerned.

Here and there in the forest reservations we find patches of thousands of young trees from 6 inches to 3 feet high running sometimes 5,000 to the acre; some reservations have few; some have simply millions.

Years ago there was a man in Denver, we used to call him Evergreen Dexter, who used to make a business of planting these young trees in the gardens of the city, and 90% of them lived.

Andrews of Boulder, is in this business today. I had him sack me up some Yellow pine, Douglas fir and Juniper and ship them to my ranch to plant on a rocky hill which I terraced; they are all alive but one; but I would say this, if men can make a business of this work and find it profitable, then there is no question but that it can also be done on a large scale by the National Government. There is little trouble in transplanting evergreens by those who understand it; the trick of doing it successfully consists in taking up a small block of earth with the roots.

Why Evergreens Often Die.

All the conifers contain a certain amount of resin and turpentine, what the farmers call pitch; this pitch acts as an anti-freezing mixture and accounts for the extreme hardiness of these trees; but it also causes the roots to be extremely sensitive when exposed to the air, for the turpentine being very volatile evaporates rapidly, leaving the resin in the roots congealed, which interferes in some way with the life processes of the tree; probably plugs up the ducts and prevents circulation of the sap. It is bad for any tree to have its roots exposed to the atmosphere but to the evergreens it means certain death.

Forest seedlings can be easily and safely transplanted with the double shovel tree planter; this implement is made on the plan of the post hole digger. The two shovels go into the ground on either side of the seedling, then the handles are brought together and locked and the little trees raised out of the ground—root, dirt and all.

The holes may be prepared a thousand miles away, the trees shipped in the transplanters by freight, dropped in the holes at their final resting place and the transplanters shipped back for another lot.

The transplanting of these trees has been done by hundreds of men and can be done by anyone who is careful; but if the dirt should by accident fall off the roots the tree should be thrown away. The best sized trees for transplanting are those from 6 inches to 2 feet. Any sized conifer, however, can be moved from one place to another; it is simply a question of taking enough dirt and roots with it, a tree 7 feet high requiring nearly a ton.

Best Time to Transplant.

The best time of the year to transplant evergreens is at the same time as any trees, before the new leaves appear while the tree is dormant. Some have been successfully moved in the dead of winter with their roots imbedded in a solid block of frozen dirt.

The Douglas fir, called also red spruce, and the yellow pine are the easiest of the lumber trees to raise and are magnificent drouth resisters, often wintering in ground where there is no perceptible moisture.

For ornament there is nothing like the juniper, sometimes called the white cedar; it is found even in the deserts and holds its own with the sage brush in the wastes of Oregon and Utah. Any of these and also the silver spruce and Norway spruce can be raised on any dry farm without irrigation, and when not obtainable from the mountains may be secured from almost any nursery. On the dry farm, however, evergreens should not be planted in adobe.

Drouth-Resistant Trees.

Among deciduous trees some great drouth resisters are the honey locust, black locust, Russian olive, elm, black walnut, catalpa and silver poplar. Any of these can be raised easily with regular cultivation. The silver poplar makes a very quickly growing windbreak and may be planted pretty close for that purpose, even 6 or 8 feet apart, but plenty of room, at least 20 feet, must be allowed between the rows. The same with the locust which have some advantage over the other trees in the fact that if for any reason they are killed back, they nearly always sprout again from the root.

In choosing trees to plant, however, winter-killing must always be considered as well as resistance to drouth, for different localities differ somewhat in this respect; but the farmer can usually obtain this information from the neighbors, the nurseries, the experiment stations or even city parks in his state or vicinity.