

Oregon Agricultural Experiment Station

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Bulletin No. 26. May, 1893.

DRAINAGE.

Address Delivered before the Marion County
Horticultural Society, Salem, Oregon.

BY

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The Bulletins of this Station are sent free of cost to all
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AGRICULTURAL COLLEGE PRINTING OFFICE.

H. R. CLARK, Manager,

CORVALLIS, OREGON:

1893.

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DRAINAGE.

(Address Delivered before the Marion County Horticultural Society, Salem, Oregon.)

During the past week, I was asked by your President to talk to you on the subject of drainage. It is a subject in which I am deeply interested, and one in which I feel that the people of this valley ought to be greatly interested.

I suppose, from what I have heard from those who came to this country in the early fifties that a large portion of the soil was then in the same mechanical condition as that which now may be seen, where it has neither been cultivated nor tramped by horses and cattle. The soil was then very loose, and old citizens have told me,— and I have no doubt about the truth of the statement,— that they could push a walking-cane down into the ground two or three feet without any particular effort.

That, to-day you could not do. There has been a change come over the mechanical properties of the soil—a change not due to the climate—the climate is all right,—but a change that is due to your methods of treating the soil. You have plowed the soil when it was wet, sometimes the water followed you in the furrow protesting, as it were, for being disturbed. You expected the rain to continue, but it did not. Then came dry weather and the sun baked the soil. This has been repeated for years. You also pastured your lands when the ground was wet, and soft, and your horses and cattle puddled the whole surface. Thus the mechanical conditions of your soil has been changed since 1850.

I know that imagination has much to do with our ideas of the past. For instance, the hills do not look so high to me in my old home as they once did—the spring is not so far away from the old house as when I carried the water. But making due allowance for all the freaks of imagination, it is doubtless true that your crops were better, that your peach and apple trees grew more thrifitly and produced better, and that your wheat and oats made a greater yield then than now.

It is, doubtless true, that, even in the fifties, the soil needed under-drainage, but in consequence of its looseness the water rapidly sank out of sight and more readily escaped into brooks and rivers. This, it can no longer readily do, because the soil has been baked and puddled until it is in many places almost impervious to water. Hence if drainage was needed in the fifties there is that much the more need for it now, and every additional year only adds to this necessity.

As I travel over this valley I see but little land that would not be great-

ly improved by under-drainage. I have seen none that did not need it. I have no doubt that there may be some such favored spot somewhere in the valley. Let me describe it. It is probably in some river bottom, the surface is from ten to twenty feet above the ordinary stage of the water; the surface soil is a sandy loam of considerable depth resting on a bed of gravel. Here the rain quickly soaks down through the loam and escapes through the gravel. If, however, there is a layer of tough clay between the loam and the gravel, the clay becomes, as it were, a bottom to the bucket and prevents the escape of the water—we call the result a marsh.

PURPOSES OF DRAINAGE.

Let us now see what the purpose of drainage is. It will be the same whether for the prune orchard or the wheat field.

All the products of the horticulturist and the agriculturist are air-plants, that is, they grow in the air—the roots as well as the tops must be in the air. Of course the roots may frequently be bathed in water but they cannot live for a great length of time in water, or under it. The main roots of the wheat, will under favorable circumstances, extend down to a depth of four or five feet; the same is true of timothy and clover. If you have any doubt about this, dig down by the side of a wheat plant two or three feet, then with a hose gently wash away the soil and you will find what I have stated to be true. The same is true of your prune and apple trees. This can only happen, however, where the conditions are favorable.

The water-table is a term used to express the level at which the water stands in the soil. During a portion of the year the water-table in this valley is almost, if not at the surface of the soil. In places it may be a few inches, and in others a foot below the surface. In many of the wheat fields which I have seen along the R. R., the land has been thrown up into narrow ridges and, in the furrows between the ridges, the water has been standing practically all winter. The water-table in that case would seem to be on a level with the bottom of the ditches between the ridges of land. If you will carefully examine such a field, you will discover that the wheat on the soil farthest above the water-table (in the middle of the land) is the most healthful, and that the nearer you approach the water-table the more weak and sickly is the plant. There is no accident about this. If you would examine the roots of these plants you would find that the main roots had been drowned by long continuance in the water and that the plants are now holding on to life simply by the lateral roots, and that those nearest the water-table had but little surface left for lateral roots. These plants show their condition by the yellow color.

That which is true of the wheat plant is equally true of the apple, plum, prune, and peach. The roots of these trees cannot live for 4, 5, or 6 months under water. To satisfy yourselves of this examine the rootlets that have pushed themselves down into the soil during the dry season, after they have been immersed for months, and you will find that these rootlets are practically dead and in many instances that the external covering readily slips from the woody part of the rootlet. Under these conditions the

plant or tree must necessarily loose its vigor and become diseased, because it has lost the power of resistance.

If you wish to determine the depth of the water-table on your lands, make an opening in the soil 18 inches square and 30 to 40 inches deep. Place the soil removed about the opening so as to prevent the surface water from entering. The depth to the surface of the water in such an opening, will be the depth of the water-table below the surface, because the water will never rise higher in such an opening than in the neighboring soil. In fact, the water will always be a little higher in the adjacent soil than in this opening. If the land be sandy loam it will be but slightly higher, but in fine clayey soils it may be much higher on account of greater capillary attraction. In properly drained lands, the water ought not to stand in such an opening.

Where there is no drainage, and when for a long period the water-table lies within a foot of the surface, the roots and rootlets which during the dry season extend below the water-table, are destroyed by the next rainy season. The effect is the same as if these rootlets were cut off at the same depth by shears. Thus the efforts of one season are destroyed before the next begins. Is it surprising that the tree, after a few years of stunted existence, should finally give up the unequal contest and die?

The purpose of under-drainage is to permanently lower the water-table to the depth of the tile. If the tiles are placed 40 inches below the surface then the water-table will be 40 inches below the surface provided the soil is not impervious to water, and the carrying away of the water from the surface, which acts like a roof on your house, will even extend the depth of the water-table so that it will be more than 40 inches.

Let us suppose that the proper amount of tile has been placed in the lands, and that these tile are properly laid, what must now take place in order that they thoroughly drain the ground? First the soil when examined under a microscope, will be found to be made up of separate particles with an interstice between them. These interstices, in properly drained soil, ought to be filled with air, but in undrained soil they are filled with water. These interstices form, as it were, a series of tubes. In that part of the soil immediately over the tiles, referred to above, the water sinks rapidly by gravity to the tile below and is carried away, but as the interstices referred to above are all connected, the water on either side of the drained portion would be forced into this portion by gravity. This would account for the drainage immediately over and near the tile.

I said that the water-table would in time be almost on a level with the tile. Let us see for a moment how this is accomplished. If the tile be only partly full of water then the water on either side of the tile would find itself unsupported on that side and would find its way into the tile. In this way we should soon observe that little channels were being cut back from the tile on the plane of the water-table. At first, these channels would be very short, only a few inches in length but by constant use these little channels containing little streamlets, increase in size and gradually extend farther and farther back from the tile.

This affords me an opportunity to express some words of caution. Don't expect too much from your tile the first year. The water *must get*

into the habit, as it were, of going into the tile and thus escaping. There must be time given for these little channels to extend laterally away *from* the tile. The first year they may not extend more than five or six feet on either side of the tile and hence only that much—a strip ten or twelve feet wide—will be drained. The next year these channels will be lengthened and so the next, so that at the end of the seventh year your tile ought to work better and drain the ground more perfectly than the first year. You will be surprised at the amount of very fine sand that escapes from the outlet of your tile drains. This sand comes from the extension of the little channels which have been cut back from the tile on the water-table. This, all takes time as was said before; hence you must be patient while the water and gravity are helping you to finish the work of drainage.

It is frequently asked how does the water get into the tile. Well it rises up on the underside, between the ends of the tile. It could only go down through the top of the tile while the whole tile is covered with water. The water all goes into the tiles at the ends of the sections. It does not soak through the body of the tile. Avoid the agent who wants to sell you porous tile. You don't want that kind of tile, the harder it is burned the better.

Suppose now that you have tiled your lands and removed the permanent water-table 40 inches below the surface, and suppose that by so doing you have lowered this water-table 30 inches; then, you have practically opened up to use 30 inches of soil that before was unused, because until the air could circulate freely through the soil no chemical changes could be made and no food for plants could have been prepared in it. Hence when you drain you prune orchards you increase the possibilities for their growth, and the old orchard which has practically used up all the valuable material near the surface now gets a new lease on life in this new soil.

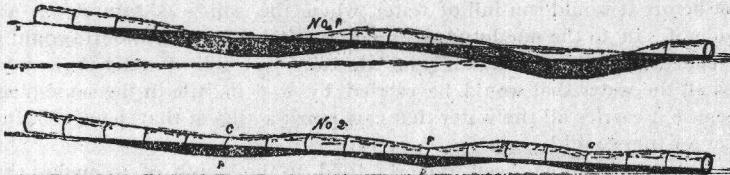
The changed mechanical condition of this permanently drained soil soon begins to show itself. The first year as you plow across the lines of the tile drains, you can readily tell where the drains are located by the lightening of the draft on the team and the friability of the soil. This condition is really more marked in the tough clayey lands than in black loams. The texture of the clayey particles is finer and the interstices smaller than in the sandy loam. The clayey soil holds more water than the loam, because the interstices although smaller, are far more numerous. This, however, only makes the necessity for drainage that much the more important. In the clayey lands the tiles must be closer together than in the loams for reasons indicated above.

It is frequently asked how close must the tile be placed. That question I cannot answer. There is no rule that can be followed. In clayey ground the tile must be closer, say from 16 to 20 feet, while in certain loams equally good drainage may be secured at 40 to 50 feet apart.

The next question which may arise is the size of the tile to be used. This depends first on the method used in laying the tile, and second on the fall or grade.

First, if the tile is laid by guess or by a water level, or rather by observing the flow of the water in the ditch, then you would better use a 6 in.

tile where a 3 in. tile would be abundant on a perfect grade, because the grade line will have many inequalities in it; and you must make an allowance for the parts below grade to be filled up with silt. If these inequalities, *up and down*, be less than six inches then some water will continue to flow from a six inch tile, as in figure No. 2 below.



Figures Nos. 1 and 2 represent tile laid on an imperfect grade. The dark portion represents the silt which has collected in points below the grade line. The light, that part not filled.

In No. 1, the tile is choked with silt at A and is useless.

In No. 2, the tile is partly filled at C, F, and G and its capacity has been limited to that of the narrowest point as at F.

The probabilities are that the inequalities will be more than 3 inches and that tile so laid, will in a few years be entirely filled with silt, and cease to be of any use as shown in figure No. 1, above. However great the care taken in laying tile, there are liable to be slight inequalities. These should however be reduced to the minimum. Where there are not more than 2 in. fall in 100 ft., and where we have nothing better than the eye to determine it, it is very easy to go from two to three inches below the true grade line without discovering it. This would cause a three inch tile to be strangulated and hence useless. If tile are properly laid on a grade of one inch to the 100 ft. it will be sufficient, in most soils. Such a grade is over four feet to the mile, which is greater than the fall in many of our rivers. For this reason I would never recommend tile to be laid by a water level. If a man were to offer to furnish the tile and lay them for nothing, and I had no immediate use for the land, I think that I would let him put them in, but I certainly could not afford to pay for it.

I would have the tile put in on as perfect a grade as possible, first because it would cost but little more to do the work, possibly not so much, and second the tile that I would then need to use would not be more than half the size otherwise needed. The cost of the tile depends on the size. Thus, 3 in. about 18 cents per rod; 4 in. 25 cents per rod; 5 in 35 cents per rod; 6 in. 50 cents per rod; 7 in. 70 cents per rod; 8 in. 90 cents per rod; 10 in. \$1.20 per rod. Now if a three-inch tile properly laid could be used where a 6 inch tile must be used, under the other methods, then it would be much the cheaper to lay the tile on a perfect grade.

To estimate the size of the tile, the amount of water to be carried away in any one day must be known. A 10 in. tile on a grade of 3 inches to the hundred feet will carry, in 24 hours, water to the depth of one inch over an area of 60 acres. The amount of water on the surface of one acre when one inch deep weighs about 112 tons. Hence a 10 in. tile would carry, at that grade, about 6,720 tons in 24 hours. A 3 in. tile would carry on the

same grade an equal amount of water from 3 acres or 336 tons. But we can rarely ever get a 3 in. tile long enough at a grade of 3 in. to 100 feet to keep itself filled with water for 24 hours. The water can't get to it fast enough. By an experiment which I made, I found that a 3 inch tile at a grade of 2 in. in one hundred feet had to be extended to a length of 700 feet before it would run full of water, when the soil was saturated. At a grade of 3 in to the one hundred feet it is probable, that the tile could be extended to 1200 feet. If the 3 in. tile runs just full of water then it carries all the water that would be carried by a 6 in. tile in the same place, because it carries all the water that can reach a tile at that point. Hence a larger tile would be useless.

When the soil has been properly tiled to the depth of 40 inches then the water-table, as has been said, has been lowered to almost that depth. The interstices between the particles of the soil are now filled with air, and when the rain comes it readily passes down into the ground forces the air out and saturates the soil. If one inch of water were to fall in 24 hours it would saturate the soil to the depth of about 30 in., and unless the rain fell very suddenly it would all be absorbed. The rain water contains a large amount of carbonic acid gas, a very necessary plant food, which is left in the soil, while the water escapes through the little channels on the water-table to the tile drains. Within the next 24 hours this water is carried away and leaves the soil ready for the next water-bath. In the meantime the air has followed up the water as it passed toward the water-table, carrying with it its heat, imparting it to the soil, and helping, at the same time to work those chemical changes which stimulate growth.

In addition to the changes in the mechanical condition of the soil, thorough drainage does another important thing, it raises the temperature of the soil during the rainy season—winter and spring—and makes the soil more moist during the dry season. These are conditions certainly greatly desired by every farmer.

In undrained lands, there are but three ways for the water to escape: first, to pass through the soil and subsoil; secondly, to flow away over the surface of the soil; and thirdly, to evaporate and escape by means of the air. Only a very small portion of the rain which falls in this valley can escape through the soil and subsoil. Hence the greater part must escape either by over-flow or evaporation.

When your head aches, you bathe your fore-head with ether—this quickly evaporates and carries away from your temples the excess of heat. Let it evaporate from your hand and you feel that your hand is colder. The evaporation of the water from the surface of the soil has the same effect on the soil and the plants—it lowers the temperature of the soil and chills the plants. The rapidity of growth of any plant depends upon moisture and warmth.

Properly drained land is therefore warmer than the undrained: first, because the amount of evaporation is lessened; and second, that which is just as important the air circulates through the soil down to the water-table and gives up to the soil its extra heat.

During the dry season the air circulates freely through well drained

lands, because it is friable; and as the soil is colder than the air it causes a condensation of the moisture in these currents of air which makes the soil moist. All know that the more thoroughly pulverized the soil, the better it withstands drought. By proper drainage 15 days may easily be gained in the spring, and the fall may be extended an equal time. Thus a month may be gained for maturing various crops.

Some one usually asks during these talks on drainage what about the roads? Well, if you will drain your farm and make an Eden of it, you will then have something to make roads for, and with. If you will tile drain your roads to the depth of 40 inches—placing a tile on each side of the road-way—raising the center of the road so that the water will run off, you will have ordinarily good roads, and especially is this true if you drain the lands on either side of the road. No energetic community need to have bad roads in this country, nor does a town or city need to have muddy streets—don't wait for sewerage, that will come later, but tile-drain your streets and grounds.

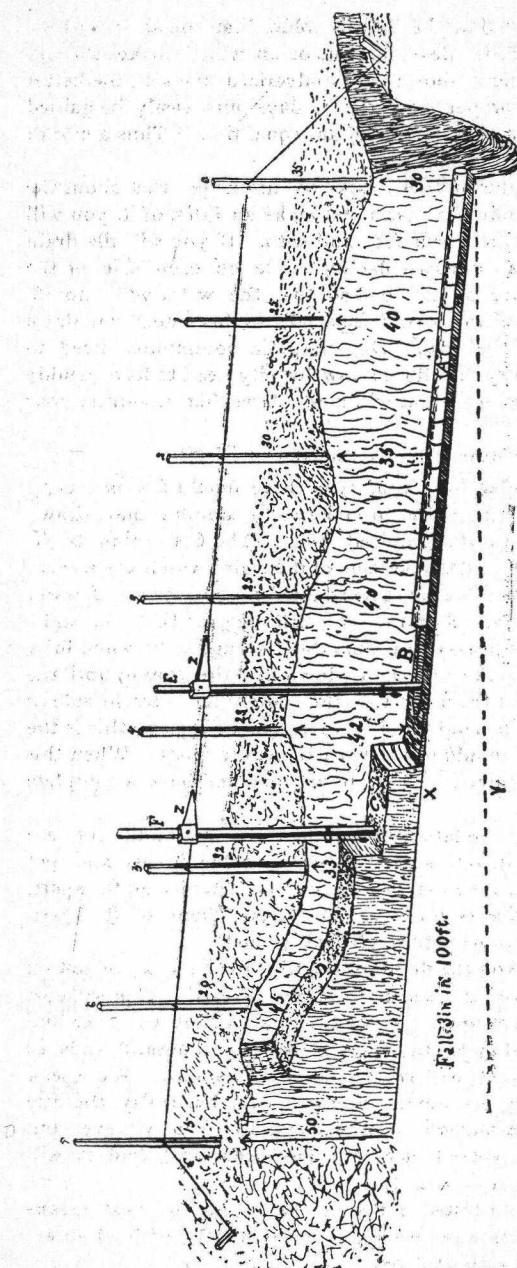
METHODS OF LAYING TILE.

In order to properly under-drain your farm there should first be a carefully prepared plan; it would be better to make out a complete map, drawn to some scale, say one inch to the hundred feet. The first thing to be secured is a proper outlet, second the position of the mains which are to carry the water away. The size of these must be adapted to the amount of water to be carried; and third the lateral drains. I would suggest that you stake out these mains and laterals just as you wish the drainage to be when fully completed. Drive a good stake 18 in. long down into the ground until the top is even with the surface of the soil; this is the grade stake. By the side of it drive in a stake two feet in length and leave one foot exposed; this is the station stake. These stakes should not be more than 25 ft. apart. When this has been done get an engineer, if you are not one, and have a complete survey made of your lands.

If your plan shows that the laterals are to be 20 ft. apart and you are not able to do all the work in one season; then put in the mains and put in lateral drains 80 ft. apart, the next year make the laterals 40 ft. apart, and the next year put in twice as much tile and make them 20 ft. apart. The same grade stakes will remain through that period.

The engineer will give you the depth of the tile at each stake or station and, if competent, can tell you the size of the tile to be used. This will cost something, but when you have once prepared for the work it will take him but a short time to level and make the calculation for a thousand rods of tile. If this is properly done it will save many times its cost. We speak of houses and barns as being permanent improvements, but really the tile drainage will be the only permanent improvements that you will ever put on your lands. A thousand years hence, if it has been well done it will still be new. Hence it should be well done.

The following device, illustrated in the cut below, is the best means that I have found for securing a perfect grade in laying tile, without an engineer to test the work as it is completed.



Here it will be observed that there are 8 stations. The survey shows the depths at each grade-stake as follows:

Stations o.....	30 in.
" 1.....	40 "
" 2.....	35 "
" 3.....	40 "
" 4.....	42 "
" 5.....	33 "
" 6.....	45 "
" 7.....	50 "

At the side of the grade-stakes, stakes about four feet in length are driven into the ground which have the station marked above them. On the side of these stakes is a hook. The first stake at o is driven into the ground until the hook is just 35 inches above the grade-stake.

This makes the bottom of the tile just 65 inches below the hook. The second is driven into the ground until the hook is just 25 inches above the grade-stake making the bottom of the tile just 65 inches below the hook.

The other stakes, it will be observed, have each been driven into the ground until the hook is just 65 inches above the bottom of the tile.

Then a wire (a fine steel wire of the kind used for holding stove-pipes in place) is stretched very taught on the ground between the two inclined stakes, and when fastened, it is then lifted into the hooks on the stakes.

This wire must be, if the survey is correct, a straight line and parallel with the bottom of the ditch, and just 65 inches above it. This wire is on one side of the ditch but not over it.

In the preceding illustration the line Y is a level or horizontal line, the line X is the grade line, and the space between these lines indicates the fall.

The difficulty in constructing a ditch for a tile drain, on a grade, may be seen in the cut on the preceding page. The upright stakes are 25 ft. apart, but it will be observed, that a different depth is required at each point. The tendency is to make the ditch at all points about the same depth below the surface. In that case the bottom of the ditch would be parallel with the surface. Thus in the illustration the first cut, the depth of one spade, about 15 inches, will have a bottom parallel with the surface of the soil, as seen at D. The second may be made in the same way, provided it does not reach the grade of the tile. In the illustration the bottom of the second cut, at C is placed on a grade parallel with the line X by means of the measure at F. The third cut is made in the same way but is made so that it lacks about $1\frac{1}{2}$ inches of being to the grade at which the tile is laid, as indicated in the figure. Then with the bottoming tool, or spoon, the bed for the tile is cut out carefully until the grade line is reached. This will be determined by the measure indicated at E. These measures are constructed as follows: the upright piece is 6 ft. long and $2\frac{1}{2} \times \frac{5}{8}$ in. This is laid off in inches. Attached to the upright is a movable arm Z about 18 in. in length having a thumb-screw for fastening it at any point on the upright. This arm is fastened at right angles. A plumb is attached to one end of the movable arm. The movable arm in this case is fastened just 65 in. from the bottom of the upright. Hence when the measure is placed vertically on the bottom, if the grade line has been reached, the arm ought to touch the wire. In this way the bottom on which the tile rests may be made a perfect grade and parallel with the wire.

It is important that the tile be placed in soil which has not been disturbed, that the alignment may not be affected by the tile settling. The tile should be laid so that the ends are brought as close together as possible, and so that the tube will be continuous.

By the method above indicated short lines of tile may be laid on a perfect grade without any survey being made, by first determining the depth of the ditch at each end and then adjusting the wire an equal distance above each end and in a straight line between these points. The height of the wire above the surface of the soil is immaterial, but it must be placed parallel with the grade on which the tile is to rest.

Those who are interested in the subject of drainage will find much of interest in works devoted to that subject by such authors as French, Manly Miles, Klipart, and Warring.

and the like; and the author of the book, who is a man of great learning and knowledge, has written a very good preface to it, which I have read with much interest and pleasure. The book itself is well printed, and the illustrations are very fine. The author's name is John Smith, and he is a native of New England. He has written several other books, and they are all worth reading. I highly recommend this one to you.

