THESIS
ON
DRAINAGE.
1881

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It may be truly said that upon agriculture depends all the others industries of the world and whatever tends to elevate and advance the agriculture of the world, better tends just so much to lift the other industries. Thus, producing more capital and consequently making the world richer. - To the general farmer the question is of more importance than the question of drainage. The farming of to-day is not, I can not be, what it was fifty or even twenty years ago. The time was when it seemed as though our western prairie land could not be abused but that it would produce abundant harvests. But that time has passed and the farmers of today are reaping the results of smaller harvests. Had they pursued a different course, the amount of their harvests might have remained undiminished.

Now what will bring our much abused land back to its former fertility? The answer will probably be better cultivation and the addition of fertilizers. Both of these methods are expensive, one costing much labor and the other costing both labor and money. The general farmer has to do more work on his land today than he did twenty years ago. And then any little help which a farmer can obtain will be of inestimable value in getting the best results from his labor and money he puts on his land in the shape of cultivation and fertilizers. How the land stands in the harvests, would mean drainage is such a help.
Drainage and its need will be especially spoken of in what follows.

Of the several kinds of drainage some will be but little more than
mentioned, while others will be spoken of more at length. Those of
which will be more particularly noticed will be natural drainage, open drains,
and closed drains or tile drains.

One of the drains not generally used in this country is the brush
drain. This drain is made by making the ditch a foot wide at the bottom,
then laying in the poles four or five inches in diameter, so that there
is an open space between them. Then lay in the brush, the closest at
the bottom, filling the ditch nearly full, taking care that the but ends lay
towards the direction from which the water flows, so as to obstruct the water
when laid in this manner. Pour in them laid carefully on this. It should
be made as compact as possible by treading. Brush drains will do well
in some localities for perhaps ten years, but will in time become useless
from filling up with sand, or from damage done them by field
burned. As a general rule it is not advisable to use this kind of
drainage.

The other mode of drainage is the metal drain. It is needless to
speak of the method of making this kind of drain. In clayey soils
this answer the purpose well for a time, but it is not durable.

Shoulder drains and plug drains are not profitable modes of drainage.
to they will be passed by. Where stone is plenty, drains are made in
much the same way as the brush drains. Stones are used instead of
brush but they have the same fault, often lasting only three or four
years.

All lands do not require drainage. Those are those lands that
naturally have enough slope to carry the water off or have a gravelly
or sandy subsoil.

The practical farmer can tell very quickly whether his land requires
drainage or not. If after a rain the ground does not become dry after
a reasonable time has elapsed and little puddles remain standing in
depressions on the surface, or if the narrow plow furrow presents a glistening
appearance when turned, or if the land becomes baked and hard in the sum-
mer, or the crops have a stunted appearance, or water grasses are found
growing, these signs and others show that the natural drainage of the
lands is not enough, and that some artificial drainage must be done.

The mode that would naturally be followed would be open ditches. In
these days when drainage is deservedly coming to have such good
pute, the open ditch is getting to be almost a thing of the past. But in
some cases the open ditch is the best method of drainage. For instance
in low, boggy, very springy land, where the muskeg is from ten to twelve
feet deep, an open ditch would be the best mode of drainage.
In such a soil tiles cannot be easily laid, owing to the amount of water and the nature of the soil. Ditches become misplaiced and filled up, and after a time become marshy. In hilly lands is subject to frequent overflow from sudden rising of streams, a good open ditch is best.

Irregularly open ditches are best aids to natural drainage, the surface of the soil only being thoroughly drained. Not draining the soil just under the surface well enough but so that in dry times the soil will be liable to bake and injure the crops of the land to cultivate.

By means of an open ditch a stream can be straightened thereby making more land and draining at the same time.

As in figure 1 it is much better to have the water take the straight course from A to B, than to follow the natural course of the stream.

One fault of the open ditches is their tendency to fill up. This fault can be remedied by making the ditch properly. Generally the way of the open ditches have been and is to make them from two to four feet wide at the top, sloping gradually down to the bottom, leaving the dirt piled up at the sides as shown in figure 2. When the dirt is piled up as represented it is very detrimental to the ditch, as it makes a pressure on that side and also forms a dam keeping the water out of the ditch.

Another fault with this ditch is that the sides do not have
slopes enough. The action of frost and water breaks down the sides in a little while and the ditch becomes useless.

The correct way to make an open ditch is to make it wide and deep and in the form of a curve instead of two slopes. Usually the ditch should be at least twelve feet wide and not less than six feet deep. The ditch should not be kept near the edge of the field but should be taken away somehow or put into piles at intervals some distance from the edge of the ditch.

Figure 3 represents a ditch made correctly. Wherever possible a team and scraper may be used to facilitate the work of opening the ditch. Ditches made in this way are not so apt to fill up by casting of the sides, because the slopes of the sides are more gradual. The dirt being put into piles allows the water to run into the ditch instead of being held and running that side of the ditch.

But the one method of draining that is the most important to the western farmer is the tile drainage, or closed drain. Of the history of tile drainage but little will be said and that will pertain especially to our own state (W.). Tile drains have been known and used for years in this country, but until within the last five years tile drainage was almost as thin in Minnesota as in the cities of the far north in this state. Now there is hardly a farm but has more or less tile drainage done upon it.
Five years ago there were perhaps perhaps five tile factories in Illinois. Now there are at least one hundred and fifty, and all of them find ready sale for all the tile they can manufacture.

Of all the modes of drainage that by means of tile is the best and the most practical, in laying tile drains the first thing is to decide where to lay them to do the most good. The mains should be laid so as to follow the general direction of the water course. Sharp bends should be avoided. If the general water course in the piece of land drained should make a sharp bend, it would be better to cut across and keep the line straight rather than to go around. Do make the bends.

The land will be almost or quite as well drained as the tile can be laid better. Before laying a line of tile one should be certain if a good out let is provided depends the success of tile drainage. This outlet should be well protected by planks or better still by stone or brick.

The fall should be determined as nearly as possible. Too much fall being nearly as detrimental as too little. The should be if possible to twelve or twelve inches to the hundred feet. If great care is taken very little fall will answer the purpose. To ascertain this fall some sort of level should be used. There are many kinds of small tools in use. To provide those used by engineers and for all practical purposes answer the purpose just as well. The level will be considered further on.
Theoretically speaking the deeper the tile is laid the wider will be the space drained. That this is so will be readily seen. For instance, say the tile is laid to the depth of three feet, at first the strip drained will be comparatively narrow; then it will be noticed that the soil will be drained to a greater distance until at last the effect ceases to be noticeable. It seems that water forms a cone towards the line of tile, and these cones extend wider and wider. The former holes required by his judgment as to the depth he should lay his tile, there being many things to be considered, such as the nature of the soil whether clayey, sandy or compact, whether the land is to be cultivated or not. In all cases the tile should be laid below the action of the frost and deep enough so they will not be disturbed by the farming implements. It is the best plan to begin by digging the ditch and laying the tile from the outlot, then the water will have a chance to run away and will also be an aid in showing directly the fall and also an aid in showing any inequalities in the bottom of the ditch. The joints should be made as tight as possible. Some times, just turning the tile to the other side up or the other end will make a joint very much better. The fall of each tile should always be the same way, this can be ascertained by laying a mason's level on the tiles every once in three or four feet. First little points should be will attacked to as upon them
depends the success of the tile drain. If in laying tile the fall is
changed it should change from a less to a greater, rather than from
a greater to a less. In Figure 4 and 5 A.B.C and a.b.c represent the
lines of tile.

In all lines of tile there is more or less of sediment or silt as it is
called. Now when the fall is changed from a greater to a less fall as in
Figure 4 this silt tends to settle and choke the tile. But if as in Figures
the fall is from a less to a greater, this silt will have no chance to settle.

In Figure 4 a silt basin should be placed at B.

Silt basins are chambers made of bricks or sometimes a large tile
stood on one end into which the water of a tile drain flows, becomes
quiet for a while, the silt settling to the bottom, instead of being
carried on to settle in the tile. The bottom of the silt basin should be
considerably lower than the bottom of the tile and the outlet from the
basin should be about the inlet as much as the fall and the depth of
the drain will allow. These basins can be cleaned out from time to
time. The amount of silt will depend upon the nature of the soil
drained, clays having less silt than other kinds of soil.

When it is necessary to branch a tile drain or to lay laterals,
branch tile should be placed on a silt basin made at the junction.
A very good branch can be made by making a notch in the side of a tile with a hatchet or some other instrument and fitting the end of another tile into it, in this way as good joints can be made as between the ends of the tiles, by a little practice. Introduce pipes or tuns directly up and down the slope for reasons that are obvious. When the land drains is liable to wet or springy at times, it is well to have the upper end of the line of tiles begin in a well or silt basin for this purpose to gather the water for some considerable distance around.

The next point is the size of tiles. Here again the farmer must follow his own judgment. A tile should be large enough to carry off all the water, but the amount of water varies. At times one size of tile works easily carry all the water; at another a tile of lower size that diameter will be found insufficient to carry the water as after a heavy rain. The farmer has to make allowances for all these variations. As a general rule one tile should be laid less than the inch-in diameter and in most cases four and five inch tines should be laid. In treated or drainage tiles, tables are made showing the sizes of tiles to be used. These are helped, but nothing definite can be ascertained and but little reliance can be placed on them. The smoothness, rate of fall, moisture of soil, and depth of
of the tile all affecting amount of flow.

The majority of the farmers cannot afford to do much thorough drainage. In fact it will not pay for the average farmer to do thorough drainage. The best plan is to drain those places that need drainage most first, then do as much more drainage as he thinks profitable. It is best to keep in view the idea of thorough drainage. In most of our farming soils fifty feet apart is near enough to lay drain.

Kinds of tile. Theoretically, the oval shape tile is the best shape for they will stand the pressure of the soil better than other shape. But everything taken into consideration the round tile, made of brick, clay, and the bent. Hoots show these are apt to be crushed in by pressure, thus ruining the drain. These should not be used on that account. The hoot tiles are better than the horse shoes tile but are apt to warp in burning and are objectionable on that account.

These should have a smooth bore, ends square and smooth cut as possible and be free from cracks and flaws.

The porosity of the tile has nothing to do with their use as to their draining capacity. The water entering at the joints and from below, that water entering from below can be readily seen. In all soils there is what is called a line of permanent saturation. This line varies with the seasons, being higher sometimes than at others.
Now the drains lower this line down to the bottom of the site. Rain may raise this line but the water will soon be carried off and the line will return to its former position.

Effects of tile drainage on the soil: It increases the depth of the soil. Water takes the place of the surface water. Chemical action takes place thereby making the whole depth of drained soil a home for plant roots. Farm roots have been known to penetrate a well drained sandy soil six, eight, and ten feet. Drainage warms the soil. No heat is absorbed by wet soil until the water at the surface has been changed to vapor, thereby taking up heat that would otherwise be taken up by the soil. Drained soil is found to be from six to ten degrees warmer, at seven inches below the surface, than undrained soil. Heat is an important chemical agent. By means of heat matter contained in the soil becomes decomposed and, mingling with other matter, makes the soil deeper and better. It is better to have the water run through the soil than to have it run over, as in the case of open ditches, for then the atmospheric plant food or ammoniae washed down by the rain is taken up and held by the drained soil.

In dry times soil below the surface is much cooler than the air and therefore it absorbs the moisture that is in the air and
WV. Cultivation that drains soil is better adapted to withstand drought. In meadow
drained land the soil becomes tarry, giving but little range for the roots while drained soil remains small giving a greater range for the roots.

Tools: - The tools needed are a spade, shovel, scoop, level, and for sticky
soils a wooden spade. A good level can be made by taking a survey's
level, placing it on a tripod. Upon this are placed two sights and a
elevating periscope. Elevation can be done with this level accurately
enough for all practical purposes. By placing the level on a base of
nos. boards of about the same length, which is connected with the tripod
by a pivot so that it may be turned in any direction. The spade and
shovel are such as can be bought at the hardware store. The wooden
spade can be made out of any hard wood as ash or oak. The scoop can
be made by any blacksmith. It should be hollowed and need to finish
up the bottom of the ditch.

Cost of tiles, tiles can be bought at the following prices at most of the
tile factories:

<table>
<thead>
<tr>
<th>Size (inch)</th>
<th>Price per 1000</th>
</tr>
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<tbody>
<tr>
<td>Three</td>
<td>$35.00</td>
</tr>
<tr>
<td>Six</td>
<td>$45.00</td>
</tr>
<tr>
<td>Seven</td>
<td>$60.00</td>
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<tr>
<td>Eight</td>
<td>$75.00</td>
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</tbody>
</table>
According to reports of manufacturers moisture and four inch tile
are sold than of other kinds.

Does it pay to tile drain? Take for instance a small slough that re-
tends through a field say for fifty rods. The soil in this slough is too
not to be tilled in the spring during the rest of the year is dry and
baked and will not produce any thing. There are thousands of just such
instances in the farmers of the west say the slough is three rods wide.
The use of an acre of land is lost. A line of three inch tile will drain
this costing perhaps $2.50. Labor and all. We see that one years crop of Corn
at 50 bushels per acre and 40 lb. per bushel will nearly pay for the tile.

Besides we have done away with the bother of dikes a slough and we
have the use of the land, which was before of no value, now becomes the
best land in the field.

Farmers should keep a plat or map of all tile lands. This may not
be very elaborate but should be sufficient to tell where the tile is.

Sometimes money and labor may be saved by taking advantage of the
lay of the land. Suppose we have fields liable to become wet from
storm fields above, which is often the case. A good example being the field
just north east of the S. W. E. it this field be represented by a
figure
The land slopes to the northwest. The water coming from the south and south-east. Now instead of running tiles as represented by the dotted lines, we put a line of large tile as represented by A.B.C. We do the same work as the other line of tile do and save all the extra labor and expense of putting in the extra lines of tile.

Tile drainage is one of the greatest helps the western farmer has, for by its larger and better crops are produced.

Surely the worse of him who said that "No, who can see two blades of grass to grow where but one grew before, is a public benefactor" are true.