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THE LOESS SOILS OF SOUTHWESTERN OHIO

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IN COOPERATION WITH THE OFFICE OF FARM MANAGEMENT, BUREAU OF PLANT INDUSTRY, U. S. DEPARTMENT OF AGRICULTURE

INTRODUCTION

By C E. THORNE

During the years 1911 and 1912 the governing board of this Station was called upon to assist in the location of county experiment farms in Paulding, Miami, Clermont and Hamilton counties—all lying in the western part of the state.

In each county the effort was made to select a farm as centrally located as possible, and accessible by good roads from all parts of the county. Preference was given to land below, rather than above the average of the county in fertility, but it was indispensable that a considerable area on each farm should be nearly level and very uniform in topography.

In Paulding county it was considered important that the farm should fairly represent the black soil which occupies the larger portion of that county, and a tract of 92 acres was selected, lying a mile and a half from the town of Paulding. This farm had two deep open ditches, giving drainage outlet; about one-fourth the tile drains necessary to proper drainage, and a small orchard, but no buildings except a one-room shanty which was afterward utilized as a kitchen; but in this condition it was necessary to pay $175 per acre to secure it, the price of land in this region having risen rapidly during recent years because of the demand for it from farmers coming from the black corn lands of eastern Illinois, which are selling at $200 per acre and upwards.

In Miami county a farm of 123 acres was purchased, lying a mile and a half from the city of Troy and on an excellent turnpike. This farm had two small houses and a barn with other outbuildings. About half of it is black land and a township tile drain crosses it. The cost of this tract was $153 per acre.

In Hamilton county a tract was purchased containing 216 acres, with a good 8-room frame house and a smaller house and two barns, about four-fifths of the land being under cultivation and the farm fronting on the turnpike and electric railway connecting the cities of Hamilton and Cincinnati, the farm lying four miles north of Mt. Healthy, now a suburb of Cincinnati, and its cost was a little under $115 per acre.

In Clermont county a farm was found lying on the turnpike and electric railway between Hillsboro and Cincinnati, 25 miles from the latter city, and containing 130 acres, every acre sufficiently level for cultivation. The buildings were a small brick house and a barn of which only the skeleton was left. The cost was $50 per acre.

So far as topography is concerned this farm is much more desirable than the Paulding county farm, for most of it possesses sufficient slope to carry off excess of rainfall readily, and to give easy grades for tile drains, yet practically none of it is so steep as to wash. Moreover, this farm has the advantage of a great market practically at its gates, ready to consume its produce of every description. Why the price of this land should be less than one-third that of the land in Paulding county seemed a question worthy of study, and therefore the investigation reported in the following pages was undertaken.

DESCRIPTION OF THE SOILS

By GEORGE N. COFFEY

In the southwestern part of Ohio, including most of Hamilton, Clermont and Brown counties, the northwestern part of Adams county, the southwestern half of Highland county, the southwestern portion of Clinton county and the southeastern part of Warren county, is found an area of soil different from that found in any other section of the state. Except in the valleys and on some of the slopes, all the soils have been formed from a silty layer known geologically as the "loess."

The loess is believed to consist of glacial rock flour ground up by the action of the ice, carried southward by the waters resulting from the melting of the ice, deposited in the valleys, and afterward swept on to the uplands by the action of the wind. In this way a

layer, with an average thickness of about 5 feet, was deposited over the uplands in the southwestern portion of the state. It is from this layer that the loess soils of southwestern Ohio have been formed.

Fig. 1. Map showing location of loess soils.

When laid down by the wind, the deposit of loess was doubtless very uniform in character and, if the drainage conditions had been the same over the entire section, only one kind of soil would have been formed from the loess. However, a difference in drainage conditions, with the consequent difference in the processes of weathering, has given rise to two distinctly different types of loess soils with all stages of gradation between them. Where the surface

is sufficiently rolling to permit the water to run off rather rapidly after rains, the soil is a yellow brown color and has been called the Cincinnati silt loam; but, where the surface is level and water remains after rains until most of it is removed by evaporation, the soil has become a very light gray to white in color and has been called the Clermont silt loam.

CINCINNATI SILT LOAM

The Cincinnati silt loam consists of 6 to 12 inches of a grayish yellow to light yellowish brown silt loam, having a rather mealy or velvety feel. Although rather friable and easy to cultivate, there is some tendency to run together and bake after a rain, especially where the supply of organic matter is low. But little change in the character of the material takes place within 36 inches, the difference being a slightly brighter yellow and heavier texture in the lower subsoil, which sometimes becomes more of a silty clay loam. Even where this is true the subsoil is never as hard, compact and plastic as some of the heavier soils of the state. Where drainage is exceptionally good, the soil has a faint reddish tinge, but where the surface becomes more level the type gradually grades into the Clermont silt loam. The gradation toward the Clermont silt loam always shows some mottling in the subsoil, while the typical Cincinnati silt loam is unmottled.

The Cincinnati silt loam covers nearly all of Hamilton county and portions of Clermont, Brown, Warren, Highland and Adams counties.

CLERMONT SILT LOAM

The Clermont silt loam consists of about 7 or 8 inches of a light gray or nearly white, rather incoherent silt loam. The soil has a very high percentage of silt with a small amount of clay and very little sand except that of the finest grade. It has practically no power of granulation, or forming into crumbs, and therefore runs together much worse than would be expected from a soil of this texture. It is easily beaten together by the rain and packs badly as soon as wet, causing some difficulty in obtaining a good tilth Where typically developed it is very ashy, and on the flattest, most poorly drained areas, iron concretions are frequently scattered over the surface and through the soil. When dry the soil appears to be white, or nearly so, in the cultivated fields, although, where drainage is better and the soil approaches the Cincinnati silt loam the color is more nearly a yellow gray.

The subsoil contains more clay than the surface soil, with almost no sand. It is a gray, slightly mottled with yellow, heavy silt loam or silty clay loam, which usually becomes drab or bluish

drab within 3 feet. On the most level areas, which really represent the most typical development of the type, a subsurface layer, consisting of a floury, mealy, almost white silt loam, almost always occurs between a depth of 8 and 16 inches. Where this subsurface layer is found the subsoil below is usually a drab gray or bluish gray silty clay, plastic and almost impervious, but not hard and compact.

Average Dates of Last Killing Frost in Spring

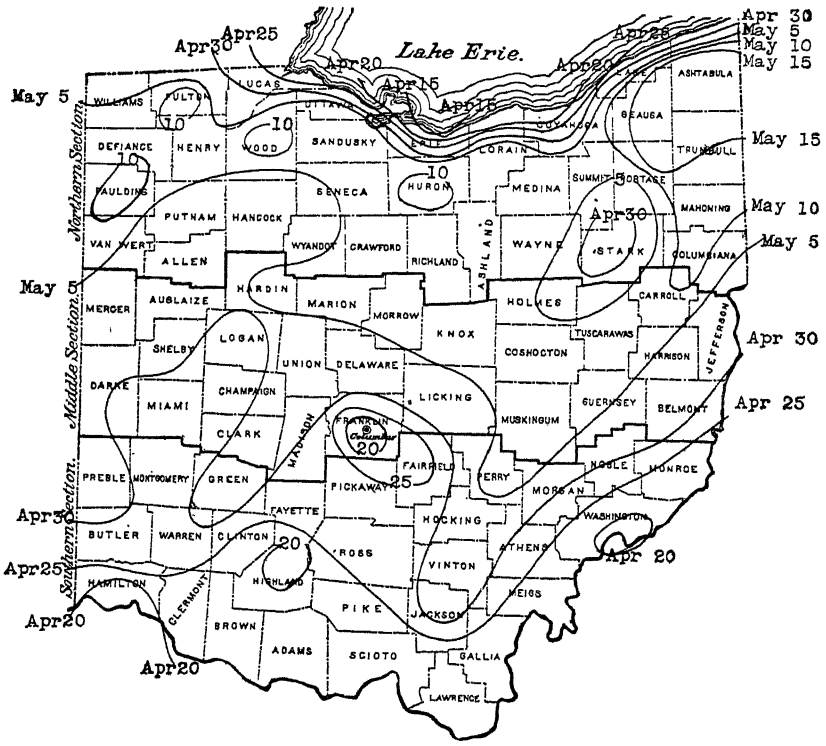

Fig. 2. The average dates of the last killing frosts of spring are indicated on this chart by lines that are drawn for each 5 days. The latest killing frosts in the spring occur in the northeastern counties at some distance away from the Lake, and there they average slightly later than May 15. They average earlier than April 20 along the Lake and in some southern districts.

The Clermont silt loam is practically confined to the level areas in Clermont, Brown, Highland, Clinton and Warren counties. However, in addition to these five counties small areas also occur in Adams and Hamilton counties. In general it occurs throughout the loessial area wherever the surface conditions are sufficiently level to permit water standing for any length of time after a rain.

REPORT OF THE INVESTIGATION

This investigation was undertaken for the purpose of ascertaining the methods employed by farmers for the improvement of their soils, especially their practice in drainage and the use of manures, fertilizers and lime and the results therefrom.

Average Dates of First Killing Frosts in Autumn

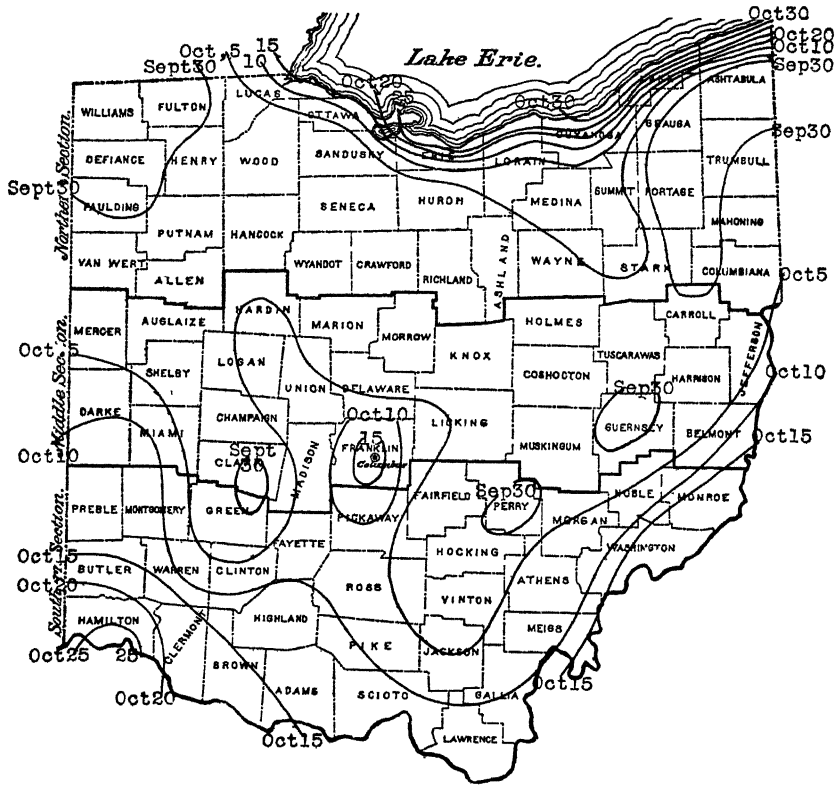

Fig. 3. On this chart lines are drawn to show the average dates of the first killing frosts in the autumn. The earliest dates are in the northeastern and northwestern counties, while the latest are along the Lake and in the extreme southwest. Both of these charts show the influence of the waters of the Lake in preventing damage from frost along the immediate lake shore. They indicate, however, that this influence extends but a very short distance inland.

In this inquiry 200 farms have been visited and 30 tile and lime manufacturers and dealers in farm supplies have been interviewed.

It is to be presumed that, after a certain type of soil has been farmed for over 100 years, the majority of farmers would have discovered the method best calculated to produce a net return on that

soil; but agricultural practice and agricultural possibilities are not always one and the same, and Dame Nature did not fit all soils for the purpose of growing modern crops.

Here was a vast area of level land, free from stones, so that modern farm implements could be used in the most economical way, with long growing seasons, the Weather Bureau showing[1] the average last killing frost in the spring to be April 25th, and the average first killing frost in the fall,[2] to be October 15th, and on October 18th, 1912 we found vegetation still growing luxuriantly.

Notwithstanding these favorable conditions, the average yields in the three counties, Hamilton, Brown and Clermont, largely on this loess soil type, have been as shown in the table below:

Ten-year average yields per acre

Period ending	Brown county				Clermont county				Hamilton county			
	Corn	Wheat	Clover	Meadow	Corn	Wheat	Clover	Meadow	Corn	Wheat	Clover	Meadow
	Bus.	Bus.	Tons	Tons	Bus.	Bus.	Tons	Tons	Bus.	Bus.	Tons	Tons
1859	30.7	10.9	...	...	33.1	12.9	...	...	38 1	14.0	...	...
1869	26.4	8.8	.20*	.82	28.1	8.5	.37*	.96	37.2	10.8	.69*	1.14
1879	30 6	9.2	.18	.77	29.9	10.2	.35	.85	36.4	13.0	1.75	1.05
1889	25.6	9.1	.23	.79	26.6	9.9	.42	.84	33.5	13.7	1.29	1.15
1899	24 8	9.6	.38	.80	25.7	8.8	.66	.82	30.4	14.3	1.47	1.07
1909	23.7	10.0	.75	80	24.8	11.1	1.09	.76	33.1	15.9	1.46	1.46

*Average for 7 years.
Note. Yield per acre for clover computed after acreage turned under for green manure had been deducted from the total acreage reported.

During the month of October, in the bumper crop year 1912, we saw hundreds of acres of corn yielding far below these averages.

But while we saw many fields with poor yields we observed others with a magnificent crop and we set about finding the cause of this difference.

At a meeting which we attended in Northwestern Hamilton county, of thirty-one farmers present but five had used commercia fertilizers, and the owner of the first farm visited gave as his experience, that fresh, coarse manure from the barn gave betterl results than well rotted manure. Seeing so much manure put in piles on the fields by the truck growers, we asked why this practice was followed and invariably the answer would be, that when spread on the land during winter it would keep the land wet and delay plowing and planting.

We found a farmer in Brown county who had put 200 rods of tile in 3½ acres of land. Before tiling, water at times would be shoe-top deep. The first year after tiling he grew 5,500 pounds of tobacco on the 3½ acres

[1]See Bulletin No. 235, pages 198 and 199, Ohio Experiment Station.
[2]See map for difference in length of growing season.

Fig. 4. No tile.

Fig. 5. Tiled.

In the same county, a farmer purchased a farm and tiled it, put it in corn followed by wheat and then clover, and in 1912 he cut the first crop of clover for hay and the second crop for seed, and sold seed to the amount of $17.50 per acre. The crops in three years, corn, hay and seed paid for the land and the tiling.

Before tiling, 5 years ago, the yields were 30 to 35 bushels of corn per acre. In 1912 a measured acre yielded 67 bushels, 15 lbs. of corn.

Fig. 6. Untiled and heavily manured.

The field of corn shown in Fig. 6 was grown on a farm of about 100 acres, 65 percent of which was in permanent pasture. An average of four horses and twenty cows were kept on this farm, quite a little feed being hauled in from outside sources to feed the cows. The manure was used on the 35 percent of cultivated land, yet the corn in 1912 would not make more than 30 bushels per acre, and the owner said he had "no luck with clover."

DRAINAGE

A great many farmers located on this soil type are of the opinion that tile drains will not work in this character of soil and even the nearby neighbors of farmers who have been successful with tile have not profited by their example.

All recognize that this type of soil needs drainage, but to get rid of the surplus water the practice has been to plow the soil into narrow lands, leaving dead furrows between for the escape of the water.

This prejudice against tiling seems to arise from the fact that some have put in tile drains and the tiles have filled up, but in every case where instances were given us that the drains did not work it was evident either that the fall was insufficient or that the outlet was defective.

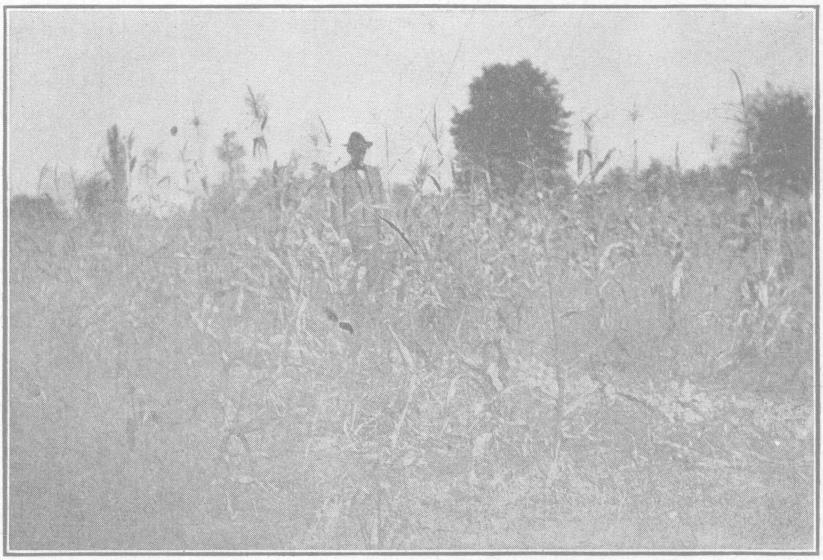

Fig. 7. Untiled and fertilized 250 lbs. of 2-8-2 per acre.

We believe that in this soil tile drains should have more fal than is required in some other soil types, although we found drains with one-eighth inch fall to the rod, with good outlets, that had been in twenty-five years and were yet doing good work.

OUTLETS

What we mean by good outlets is that they should be open, so that in times of excesssive rainfall the water may run away freely and will not back up in the tile. On one farm we found an 8-inch tile one-third full of iron concretions.

Farmers usually refer to these concretions as black sand. They are of the appearance of rusty iron and can readily be crushed between the fingers. This drain did not have sufficient fall near the outlet and emptied into a ditch on the public highway, and where the ditch crossed the highway the stone culvert had caved in, causing the water to back up in the tile, and the iron concretions, with some of the sticky silt were deposited, and though afterwards the

water ran away the tile did not clean. Some material taken from these drains was sent to the Experiment Station and we here quote from a letter by Dr. Coffey.

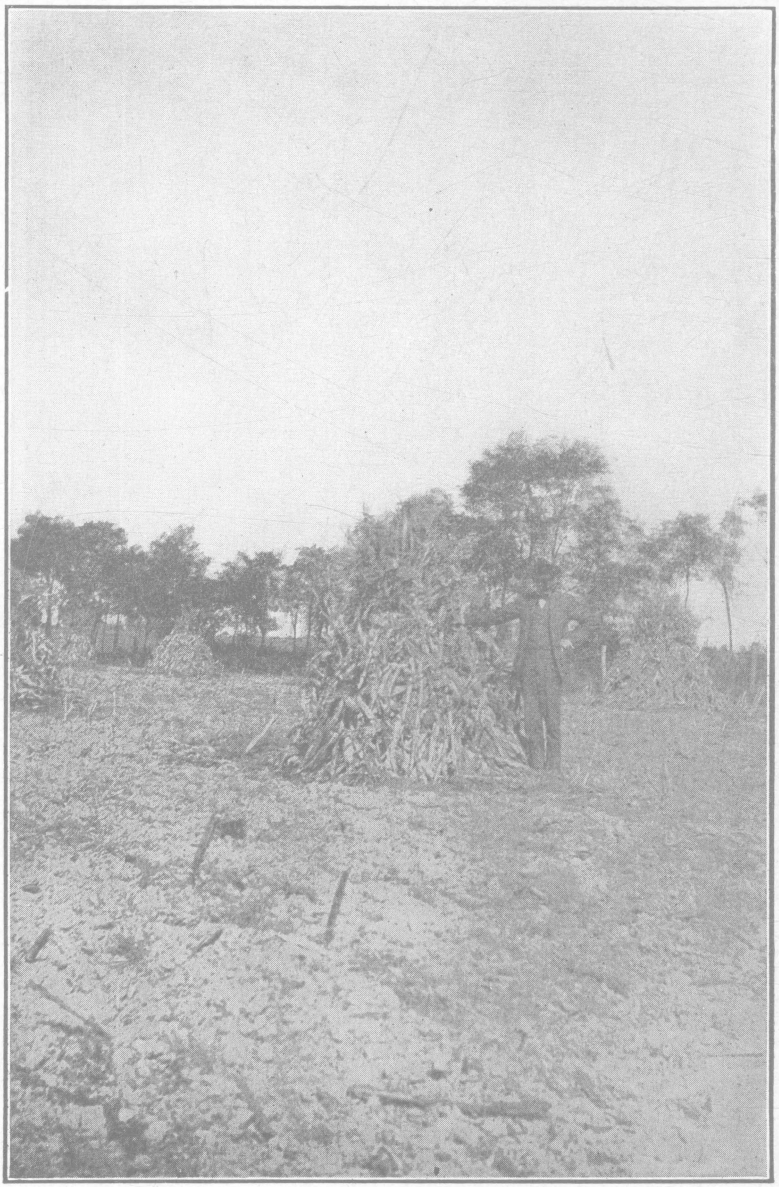

Fig. 8. Tile and manure. Some places on this farm would not grow anything before tiling, 20 years ago. It now produces 60 bus. of corn per acre.

"The specific gravity of this material, as determined by Mr. Tuttle, is 3.8 while that of soil is usually taken at 2.65. You will see therefore that it is quite a little heavier than ordinary soil. About 60 percent of the total is coarser than a 20-mesh screen, while about 20 percent is larger than one-half inch on longest diameter.

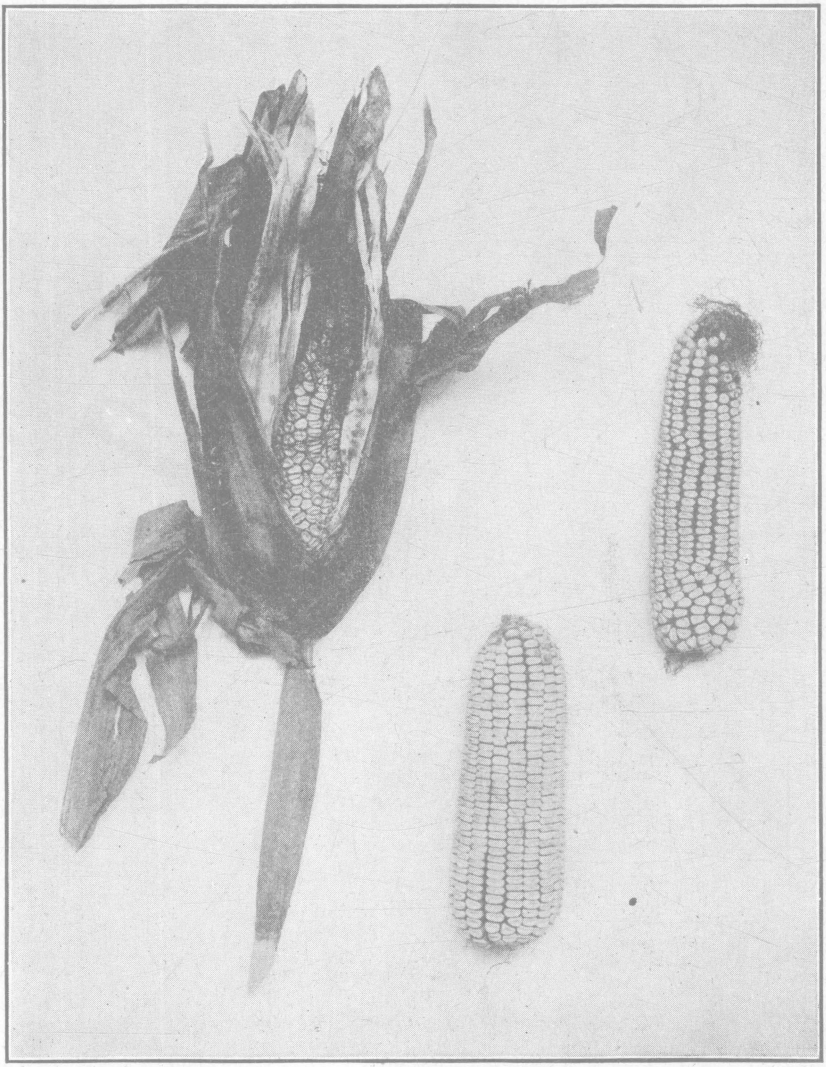

Fig. 9. Ears of corn from untiled land.

"According to the calculations of Hopkins the capacity of a current to transport material increases as the 6th power of the velocity; that is to say, the motor power is increased 64 times by doubling the velocity. The following table, from Geikie's Text Book of Geology, will give you an idea of the size of the particles which will be carried by different velocities.

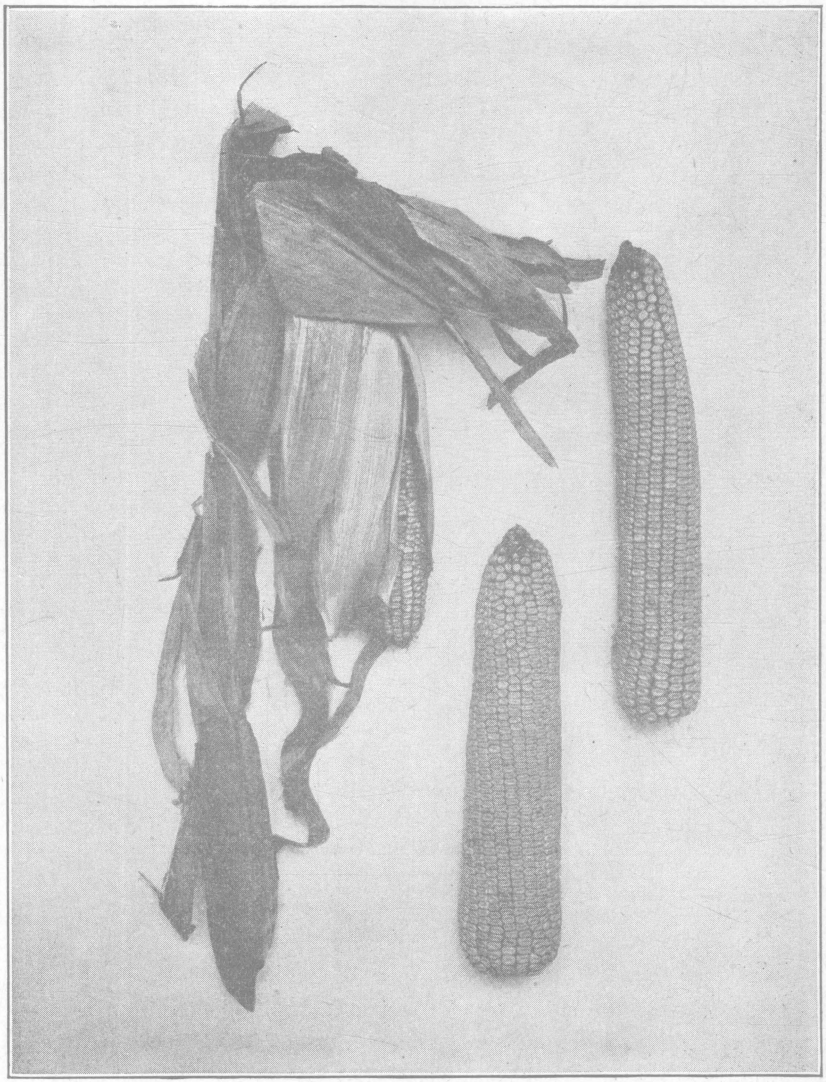

Fig. 10. Ears of corn from tiled land. Drainage, therefore, seems to be the key to the situation.

Inches per second	Miles per hour
3	or 0.170, will just move fine clay
6	or 0.340, will lift fine sand
8	or 0.4545, will lift sand as coarse as linseed
12	or 0.6819, will sweep along fine gravel
24	or 1.3668, will roll along rounded pebbles 1 inch in diameter
36	or 2.045, will sweep along slippery stones the size of an egg."

In one instance we found a 6-inch tile half full of the sticky silt, and on taking up a tile it was found difficult to clean out and though the outlet might be opened we doubt if this tile would ever clean out.

From our observation we would conclude that good and uniform fall is necessary, that all outlets should be kept open so that the water can flow out freely, and that in joining laterals they should enter at an acute angle, with a drop of two or more inches, so as to increase the velocity and motive power of the water at that point. Joints should be made close so as not to admit iron concretions of large size. Just how these concretions get into tile is not known to us, but crawfish are probably an active agent.

Fig. 11. Eight-inch tile one-third full of iron concretions.

DEPTH OF DRAINS

Many farmers think that tiles in this soil should not be put in more than 24 inches deep for best results, but we found tiles in some instances 3 feet deep that had been in a number of years, and were doing effective work. There was almost an agreement of of opinion that the longer tiles were in the better and farther they would draw. We think the opinion that tiles should not be put in

deep is founded on the observation that the first year the effect on the growing crop is only noticeable immediately over or near the tile, some giving as their observation that it only effects three rows of corn. But on one farm, where a tile drain had been put in 3 feet deep in November, 1912, on April 30th, 1913, two days after a heavy rainfall, by boring with a soil auger we could notice the effect on the soil at a distance of 2 rods, by the crumbly condition in the hand, while at 4 rods distant mud balls would form.

This drain was made by a machine when the land was dry and puddling of the soil was avoided. Some people speak of this soil being hard-pan and say that water will not readily percolate through it, but we were much surprised to find that in ten days after the flood rains of 1913, tiles were practically dry in this soil type, while in counties adjoining on the north, with Miami or Bellefontaine soils, much water was yet running in the drains.

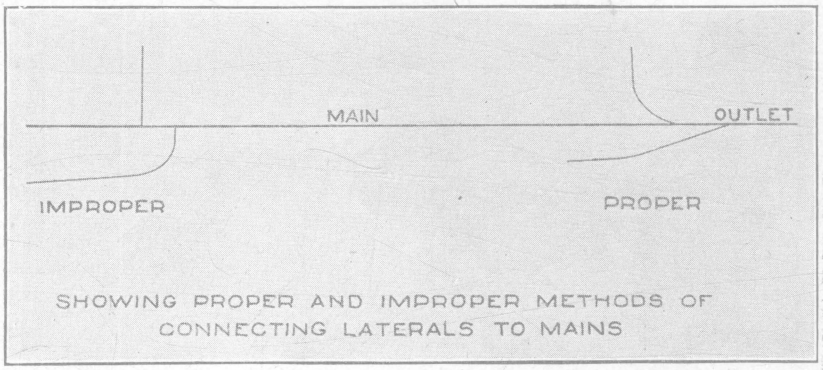

Fig. 12.

SIZE OF TILE

Most farmers state that it is their observation that a 4-inch tile draws the water out of the soil much more quickly than a 3-inch, but we found one farm where 2-inch tiles had been in 23 years and were working well. At the present time but few tiles less than 4 inches in diameter are being laid.

DISTANCE APART

Quite a difference of opinion exists as to the distance the drains should be laid apart in order to effectively drain the soil. Apparently the deeper they were in the farther they would draw. In new ground they would draw farther and work better than in old ground. More than 4 rods apart did not seem to give good results, and the few drains we found less than 4 rods apart seemed to be giving the best results.

Many have put tiles only in the "draws" or low places. When the rains come the excess water runs to these low places and not being able to get into the tiles runs off over the surface. Men who have made a success of tiling lay the mains through the draws or low places, and then run laterals, not at right angles but in such a way as to intercept the water before it reaches the mains.

COST OF TILING

Four-inch clay tiles cost from 22 to 24 cents per rod at the factory; cement tiles as a rule cost a little more. As to the effectiveness of the clay or cement tile, one seems to be as good as the other, although cement tiles have had but a few years trial. Some users of cement tiles claim they are superior from the fact that water will readily percolate through their sides, but this does not hold true of all cement tiles.

To open the ditch 2 feet deep and "bed" the tile by hand costs in some places 18 cents per rod, in others 25 cents per rod.

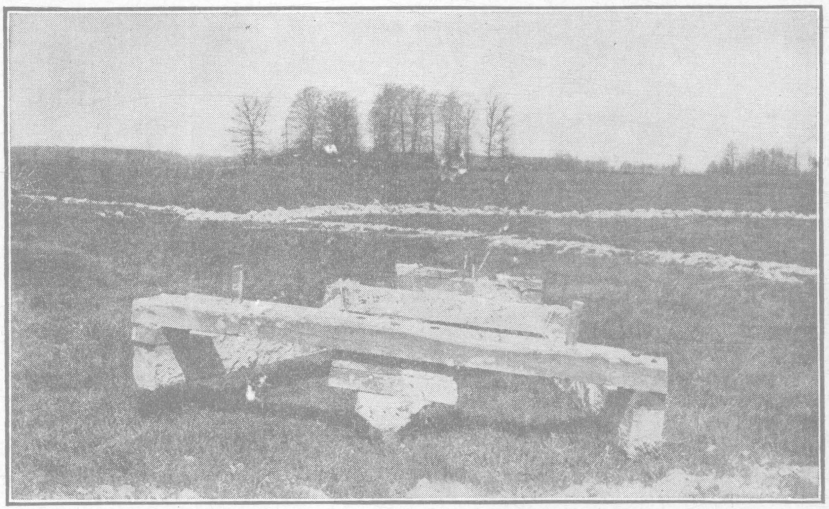

Fig. 13. Home-made implement for filling ditches. The block in the center extends below the level of the V-shaped frame and prevents the implement dragging from side to side.

Two kinds of ditching machines have recently been used to some extent, the tractor and the six-horse plow. Those who have used them seem to think that they can do the work more cheaply with machines and as effectively as by hand. One seeming advantage with some machines is that the work can be done and proper grades made when the land is dry, thus avoiding puddling.

One field of 12 acres that had been ditched by a horse ditcher, in the fall of 1913, with a 6-inch main and 4-inch laterals, 4 rods apart and 26 inches deep, had cost $242.50, or approximately $20 per acre.

THE EFFECT ON THE LAND

Most farmers think they can work their soil, if tiled, ten days to two weeks earlier in the spring than they could before tiling. In boring with the soil auger the earlier workable state of the soil on tiled land as compared with untiled was quite evident.

Tiled land can be plowed with less draft on the team than untiled. Usually the crops are more than doubled in a few years. Clover will grow and with the clover comes increased net farm revenue.

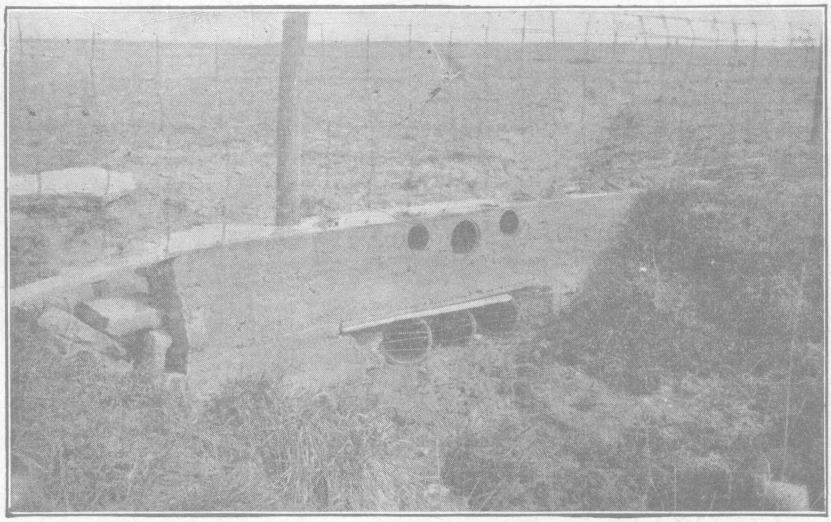

Fig. 14. Protecting the outlet.

SOIL AMENDMENTS

In Hamilton county much manure is hauled from Cincinnati, the price of the manure usually being 50c per load, and the cost of hauling and distribution on the land depending on size of the load and distance to haul. Where this manure is used many farmers and truckers think that fertilizers do not pay. Beyond this manure belt more fertilizer is used and as a rule it is a potash mixture, 6-10, 8-8 or 10-2.

On a very great portion of this loess soil type, without tile drainage we think the addition of amendments, such as fertilizers, manure and lime, is a waste of time and money.

As a rule, the Cincinnati manure has heated, much of the ammonia has been driven off and the potash leached out. The quantity necessary to apply on the land in order to open up and aerate the soil makes the cost of production great.

Much of this land has been farmed for over 100 years. Clover never did do well (see page 2) and other legumes are not much grown.

Timothy hay has been grown on much of this land as a cash crop for years. We could not find that it was the practice of farmers to fertilize the timothy hay crop.

Seldom are any crops plowed under. Under such conditions it may be that some potash is called for in the fertilizer, but on examining a number of corn fields in 1912, we found a nubbin pretty well filled, but the stalk seemed small in proportion to the ear, showing a lack of nitrogen.

In the matter of legumes, cowpeas and soybeans should be grown to a much greater extent. These have been tested on a few farms and can often be grown where the clover fails.

As live stock has not been extensively kept for many years and the crops grown have mostly been sold off, the land is very deficient in organic matter. Green crops plowed under would very materially improve the land. One farmer has used rye, buckwheat and corn to plow under and thought this, combined with fertilizer, was cheaper than hauling so much manure from Cincinnati, which he estimated cost him $2.00 for a four-horse load spread on the land. This was on well tiled land.

ROTATIONS

It is probable that the rotation needs to be changed and a visit to the Hamilton county and Clermont county experiment farms, especially noting the 4-year rotation of corn, soybeans, wheat and clover, would be time well spent.

LIME

In traveling over the roads it was quite noticeable that along limestone pikes the clover would be better than farther back in the fields. In the few instances we could find of lime being used it seemed to give good results and the soil by litmus paper and acid test shows marked deficiency in lime. We also notice that, wherever the streams have washed down through the loess soil there is a bed of limestone, so that it would seem that the introduction of a portable limestone crusher should be of very great advantage to the country.

In the matter of distributing fertilizers for corn, we find that applying with the corn planter is a method that is increasing rapidly, several dealers reporting that all planters recently sold have the

fertilizer attachment. Some farmers have noticed that, when the fertilizer is applied with the corn planter, the corn starts nicely but at earing time does not fulfill its early promise. It would seem that the best results have been obtained by putting on the greater part of the fertilizer broadcast, then adding a small portion in the planter to give thecorn a quick start.

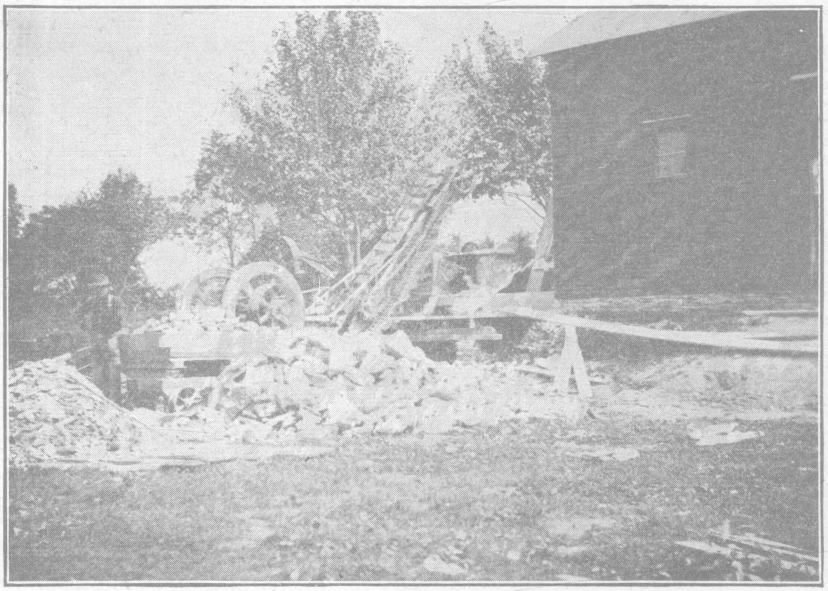

Fig. 15. Portable limestone crusher.

The use of the manure spreader is on the increase, those who have used them claim that the spreader lessens the cost of applying the manure to the land, and by a more uniform distribution makes it possible to cover more land.

In the production and handling of manure very few cement floors are found in the barns, and practically no use is made of acid phosphate for reinforcing. Where the testimony to the good results from the use of manure is so universal, it would seem that a study should be made of Bulletin No. 246 and Circular 144, Ohio Agricultural Experiment Station, on the production of manure and reinforcing of the same, and much attention should be given to putting their suggestions into practice.

On traveling over the district covered by this soil type, one can but be impressed with the idea that farming has not made the advancement here that in has in some other portions of the State, and the question arises as to why this condition. We can but think that

the prevalent idea that tile will not work on this soil has had much to do in impeding agricultural progress. As to the future, we think it depends on how prevalent the practice of tiling becomes.

Many farmers are so located that good outlets cannot be obtained except by county and township ditches and through some other man's farm. But where the land is properly tiled we are inclined to look upon the future somewhat as a gentleman who had recently come into this soil belt from the corn belt of Illinois, who said, "I came from Illinois, where they sell land at from $150 to $200 per acre. This farm cost me $55 per acre, and I expect it to cost me $35 per acre to systematically tile it, but when I get it tiled it will grow as much corn as they grow in Illinois on land that sells for $150 per acre."

Draining alone will probably not accomplish this result, but when drainage is supplemented by systematic crop rotation and intelligent use of manures and fertilizers there can be no doubt that a revolution will be effected in the agriculture of this region.