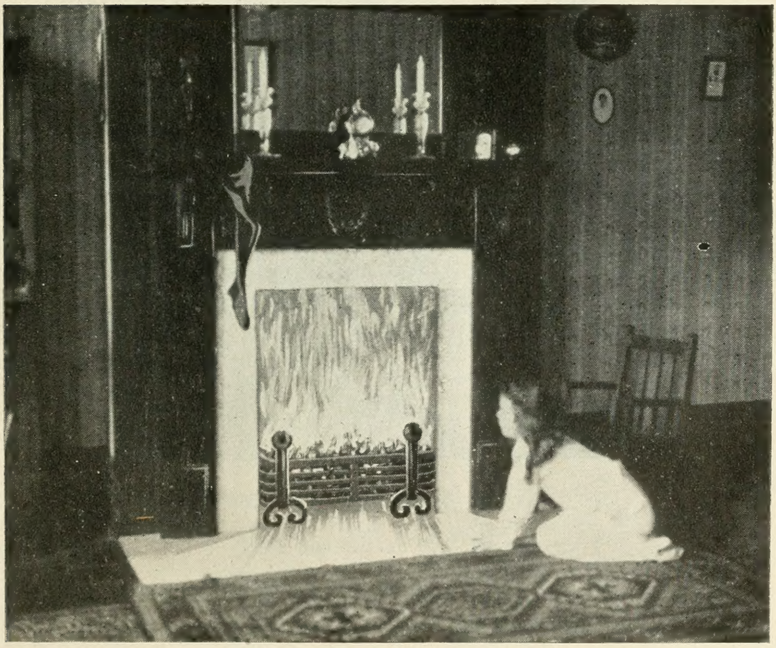
# The Agricultural College

EXTENSION BULLETIN

Vol. VII. DECEMBER, 1911. No. 4

# SOIL DRAINAGE

By A. G. McCALL,
Professor of Agronomy.



Size the fire-place up an' figger how ''Ole Santy'' could
Manage to come down the chimbly, like they said he would.
Wisht 'at I could hide an' see him—wunder what he'd say
Ef he ketched a feller layin' fer him thataway!

From Riley's "Child Rhymes."

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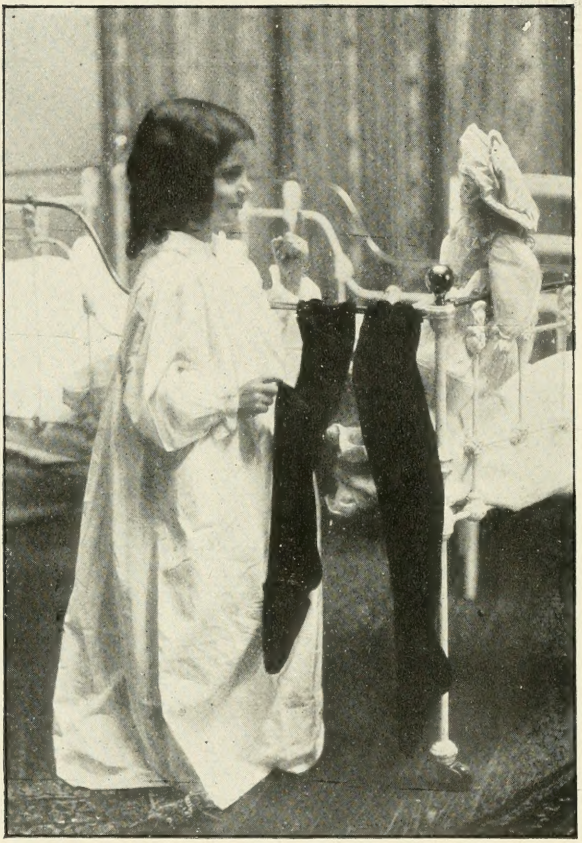

From "Boys and Girls," Ithaca, N. Y.

"I know what will do for our baby,
I've thought of the very best plan;
I'll borrow a stocking of grandma,
The longest that ever I can."

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The College of Agriculture will help teachers and others to name plants, insects, fruits, etc., from specimens mailed or expressed. Our desire is to see Nature Work and Agriculture successfully pursued. Occasionally an instructor may be secured for some special instruction in Dairying, Horticulture, Soil Fertility, Animal Judging, or Farm Crops.

A. B. GRAHAM, Supt. Agricultural Extension.

## A CHRISTMAS WISH.

I'd like a stocking made for a giant,
    And a meeting house full of toys,
Then I'd go out on a happy hunt
    For poor little girls and boys;
Up the street, and down the street,
    And across and over the town,
I'd search and find them every one
    Before the sun went down.

One would want a new jack-knife,
    Sharp enough to cut;
One would long for a doll with hair,
    And eyes that open and shut;
One would ask for a china set
    With dishes all to her mind;
One would wish for a Noah's ark
    With beasts of every kind.

And some would rather have little shoes
    And other things warm to wear;
For many children are very poor,
    And the winter is hard to bear,
I'd buy soft flannels for little frocks.
    And a thousand stockings or so,
And the jolliest little coats and cloaks
    To keep out the frost and snow.

I'd load a wagon with caramels,
    And candy of every kind;
And buy all the almonds and pecan nuts
    And taffy that I could find.
And barrels and barrels of oranges
    I'd scatter right in the way;
So the children would find them the very first thing
    When they woke on Christmas day.

—From Youth's Companion.

# SOIL DRAINAGE

**By A. G. McCall.**

The soil is a mixture of very fine rock particles and decayed organic matter from plants and animals. However, this material does not occupy all of the space. In dry clay soil about one-half of the space is taken up by the soil particles and the other half is occupied by air. In sandy soils the individual air spaces are larger than in clay, but there are fewer of them and they take up only about one-third of the entire space.

**Exercise**—Fill a quart can with dry soil or sand to within a quarter of an inch of the top. Carefully pour water on the surface and allow it to soak into the soil until all of the air space between the particles has been filled and the free water stands at the surface. The quantity of water used will be the measure of the pore space.

For the best growth of crops about one-half of the space not occupied by the soil particles should be divided equally between air and water. If this space becomes entirely filled with water, crops will not thrive, since their roots will not be able to get the air necessary for plant growth. Some plants, such as the cypress and the water lily, have special structures which enable them to obtain air from the water while their roots are entirely submerged, but our common field plants do not have this power.

The water that falls on our fields as rain would in time completely saturate the soil if no drainage were possible. The more nearly level the land, the more readily does the rain pass into it. During a long continued rain the water soaks into the soil until, like a blotter or sponge, it can hold no more. Then the excess of water will flow over the surface to the lowest points in the fields and finally join the creeks and rivers which are a part of Nature's great drainage system. At the same time, the water which has passed into the soil gradually soaks into the subsoil and eventually finds its way to the streams. If the soil is a loam or a sandy soil, this natural drainage will be sufficient. In the case of most clay soils nature does her work too slowly to be of immediate benefit. Then it is that we should supply artificial drainage to carry away the water more rapidly and thus assist Nature. If the land is quite level, both open ditches and tile drains may be necessary to accomplish the desired results.

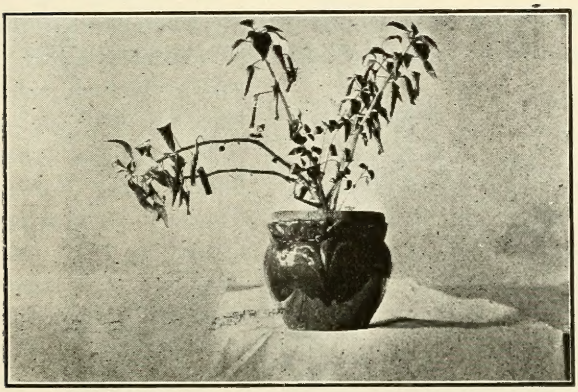
Good drainage, then, is the first essential of a productive soil and the foundation upon which all permanent soil improvement must be built. If good drainage is lacking, the benefits which should come from manuring and thorough tillage will not be realized to their full extent. For their best growth, plants should have a moist but not a wet soil; lack of moisture causes the leaves to curl and wither, and too much water in the soil causes the plants to become spindling and yellow.

**Exercise**—Fill two cans with moist soil and plant in each four grains of corn. Place the cans in a warm room and water the soil occasionally until the corn is three or four inches high. Then add sufficient water to one can to saturate the soil completely. Observe the effect upon the corn plants. Finally, punch some holes in the bottom of the can and allow the excess of water to drain away. From time to time compare the plants growing in the two cans. It will be observed that the complete saturation of the soil causes the plants to turn yellow and show lack of vigor. The restoration of good drainage conditions will bring the plants back to normal appearance.

## Benefits of Good Drainage.

Good drainage benefits the soil in many different ways, the most important of which are the following:

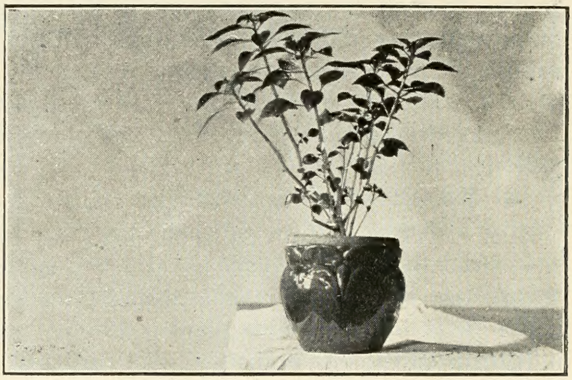
1. Drainage assists the soil in maintaining the amount of moisture necessary for the best growth of crops. After the excess of water has drained away, a thin film of water remains around the soil particles. It is this film moisture that is most useful to the plant, because it supplies the growing rootlets with food dissolved from the soil, but does not prevent the free passage of air into the soil.



Periwinkle wilting on account of the lack of film water.

**Exercise**—Thoroughly clean a glass marble and dip it into a basin of water or oil. The film of water or oil covering the marble corresponds to the film moisture which covers the surface of the fine soil particles.

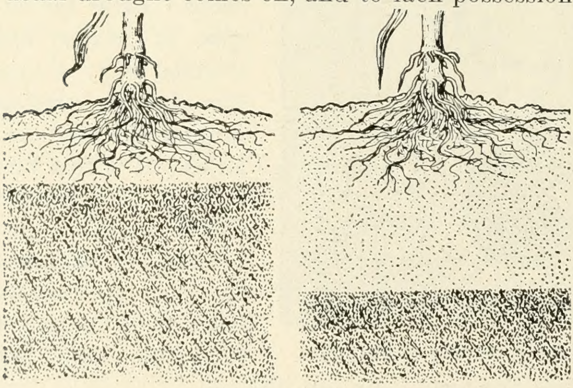
After a long dry period this film may become so thin that the plant roots will no longer be able to secure sufficient moisture and the plant wilts, as shown in the accompanying photograph of the periwinkle.



The same plant 24 hours after a liberal application of water.

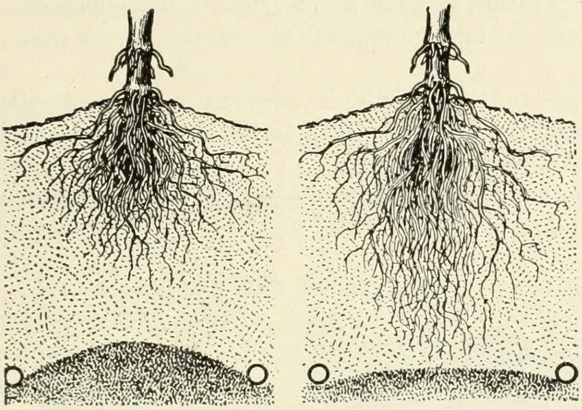
2. Drainage, by encouraging a deep root system, enables the crops to withstand dry weather better. In heavy, undrained soils the water passes downward so slowly that the plants in their early growth send out only a very shallow root system, because the standing water, or water table, is so near the surface; our common plants will not send their roots into free water to any great depth. In time, the water makes its way down far below the roots of the plant; a drought comes on and the plant suffers, because the root system in its early life could not extend deep enough to enable it to find sufficient film water from which to draw its moisture during the dry period.

For example, corn that was planted in a wet soil in May will be found to have made but shallow root development by August, when the usual drought comes on, and to lack possession of a sufficient depth of soil to furnish moisture for this trying time. On the other hand, the well-drained soils that are dryest in May usually have the largest amount of available moisture in July and August, because the larger root development in this land places the plant in contact with a larger amount of soil during the late summer drought.



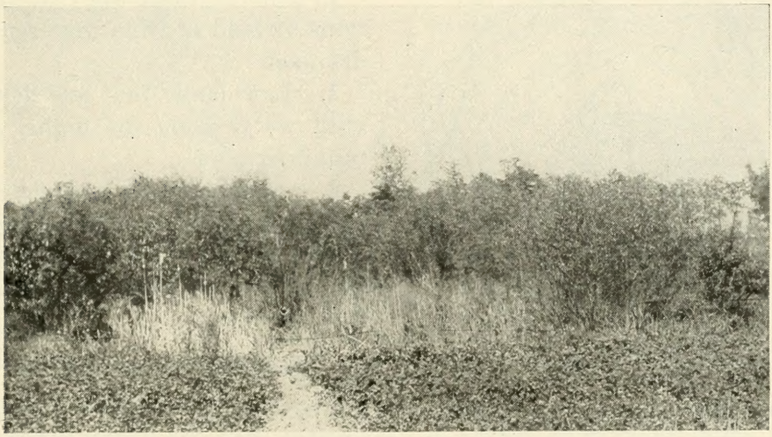
Corn planted on a poorly drained soil will have a limited root development and will be unable to withstand the later summer drought.

The deeper the soil conditions will permit a tile drain to be placed, the better the results will be. The space between the water table and the mulch at the surface represents the territory in which the roots may obtain plant food. The better the drainage, the larger the supply of food which the plant can use. This may seem contradictory when one is reminded that the underdrain carries away dissolved plant food. But the gains from drainage are in every way far greater than the losses.



**On well drained soils the corn roots strike down deep into the soil and are able to secure moisture from below during the dry portion of the season.**

3. Drainage makes the soil warmer. Soil that is saturated with water warms in the sunshine very slowly, as compared with a soil that is well drained, because the amount of heat required to raise the temperature of a pint of water one degree is about five times as great as the amount necessary to raise the temperature of a pint of dry soil one degree. A drained soil warms up more rapidly in the spring and permits an earlier planting. This lengthens the growing season and insures early maturity, which is an important consideration, especially in the case of early garden crops.



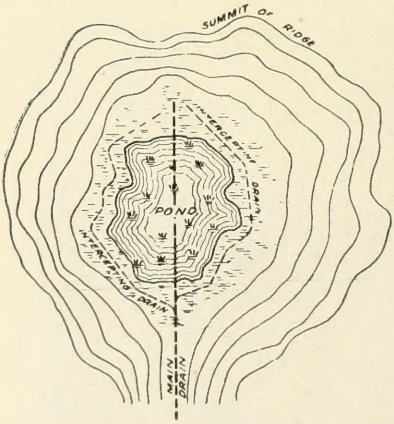
**Low swamp land—waste land in every sense of the word, since it yields no crop and is a menace to the health of the community.**

**Exercise**—Fill one can with water and another with dry soil. Place both cans in the sunlight and at the expiration of 15 or 20 minutes read the temperature of each by inserting a thermometer until the top of the bulb is one inch beneath the surface of the material in each can.

The drainage of wet land is a paying investment and in many instances the increase in the value of the crop is sufficient to pay, in a few years, the entire cost of the drainage.

The accompanying photographs show the results of drainage on an Ohio farm in Champaign county.

**The same field, growing a fair crop of corn, one year after it had been drained. It will require three or four years to get the full benefit of the drainage.**




**For low basins that are flooded from higher lands the remedy is simple.**

In general, there are two conditions of land in Ohio that require drainage.

1. Low lands that are flooded with water from the higher surrounding land.

2. Comparatively level fields or rolling tracts of heavy clay soil on which the water stands at or near the surface for several days after a heavy rain.

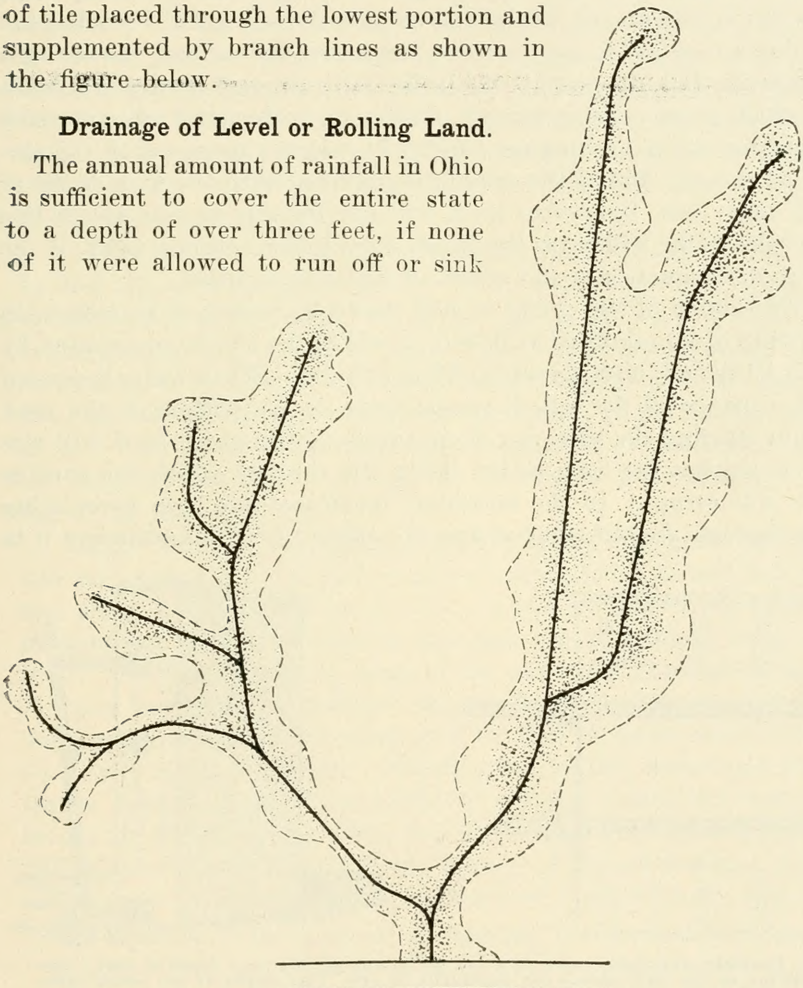
### Drainage of Low Lands.

For most low lands that are flooded from the higher lands, the remedy is quite simple. These lands are in the form of a basin, the bottom of which is impervious. Drainage is accomplished by cutting a deep open ditch through the rim of the basin or providing a large tile through which the water may escape to the nearest stream. This may be supplemented by lines of tile or open ditches which will intercept the water as it flows from the higher levels as shown in the diagram (Page 8).

Strips of low, wet land may also be drained by the use of a line of tile placed through the lowest portion and supplemented by branch lines as shown in the figure below.

**Drainage of Level or Rolling Land.**

The annual amount of rainfall in Ohio is sufficient to cover the entire state to a depth of over three feet, if none of it were allowed to run off or sink

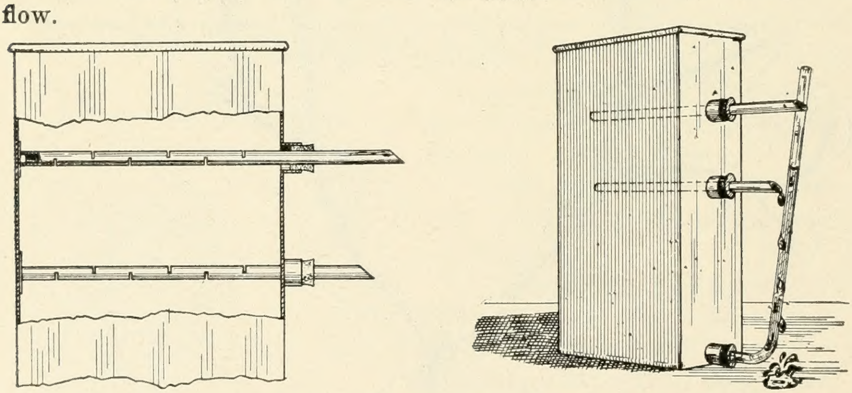


**Strips of wet land may be drained by lines of tile placed through the lowest portion. The parallel lines at the bottom represent an open ditch or creek.**

into the soil. On level lands a large amount of this water soaks into the soil and raises the level of standing water found at some depth in all soils. Unless drainage is provided, it is only a question of time until the standing water will rise to the surface after a heavy rain and injure the roots of growing crops. This rise of water may be prevented by placing lines of tile some distance below the surface, sloping them gradually to a common outlet.

There is a mistaken idea that when rain falls upon land that is tiled, the water will percolate through the soil until it reaches the tile and then enter the drain from the top and run away. After a heavy rain, the water settles almost straight down into the soil until it reaches the standing water, which may be many feet below the surface. As the rain continues to fall, the water level in the soil rises as it would in a basin into which water is being poured; finally, the water level will approach the surface and if nothing prevents, will continue to rise until the surface is reached. But if the ground is provided with tile at a depth of about three feet, the water level will not be able to rise above this point; the water will enter the joints from below and run away, if the tile are of adequate size and provided with a free outlet.

This action of tile drains is well shown by means of an apparatus consisting of a tank filled with soil, in which the tile is represented by two small slitted tubes placed at different levels. When water is poured on the surface of the soil, it passes down to the bottom of the tank without starting the tiles, but if we continue, the water level will rise until it reaches the level of the lower tile through which the surplus water will escape. In the meantime the water has been percolating down through the soil surrounding the upper tile without causing it to flow.



**Drainage apparatus used to show the action of tile in a drained soil. The drawing at the right shows the apparatus in use. The height of the water table is indicated by the level of the liquid in the glass tube. The figure to the left is a cross-section showing the slitted tubes in place.**

## Drainage Practice.

The first step in the construction of a drainage system is the location of the outlet which must of necessity be lower than the land to be drained. Where the land is slightly rolling this is a comparatively easy matter since the general direction of the slope of the field is apparent and streams or open ditches are not difficult to reach.

The drainage of many large areas of flat land, however, involves the construction of large county ditches to furnish outlets for the tile and open-surface ditches.

After the outlet is located, the next step is the location of the main line of tile. If the land is slightly rolling the main drain should occupy the lowest part of the field and follow the general slope as far as possible so that the laterals or side drains may slope toward the main tile. The location of the laterals will be determined by the contour of the field. As a general thing, they will be spaced at irregular intervals and with the main will form an unsymmetrical branched system, as shown in the figure on Page 9.

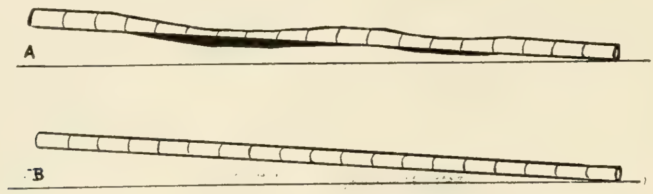
If the surface is comparatively level, the drainage system should be laid out on symmetrical plans. These plans require an open ditch or a main line of tile across the lowest side of the field at right angles to the general slope of the surface. The laterals are placed at regular intervals parallel to each other, and at right angles to the main ditch, if the long side of the field borders on the ditch. If the field is long and narrow with the short side bordering the ditch, it will be best to provide one long main at right angles to the ditch with short laterals branching off at regular intervals.

After the most desirable system has been determined, the laterals and mains should be located by guide stakes placed at intervals of 100 feet along the proposed line of tile. If the surface of the land has a decided slope the ditch may be dug and graded without the use of a level. The digging should begin at the outlet and proceed up the line. If water is available, a uniform fall may be secured by carefully cleaning out the bottom of the ditch until the flow of water toward the outlet is uniform at all points. Where a fall of two inches per hundred feet is desired, it may be obtained by placing a dam two inches high across the bottom of the ditch at a point where the desired grade has been reached and cutting out the bottom of the ditch above until the water backs up to a point just one hundred feet above the dam.

**Exercise**—This method of securing the desired fall may be demonstrated on a small scale in the school yard or adjacent field.

Drains which have a fall of two to four inches per hundred feet will prove entirely satisfactory if the work is carefully done. Where it is possible, the grade should not be less than two inches per hundred feet.

Great care should be exercised to have the bottom of the tile on a smooth, uniform grade. If the tile are out of line, silt will collect at the low points and clog the drain. The grade of the main drain should increase toward the outlet since this will increase its carrying capacity and stimulate a more liberal flow from the laterals.

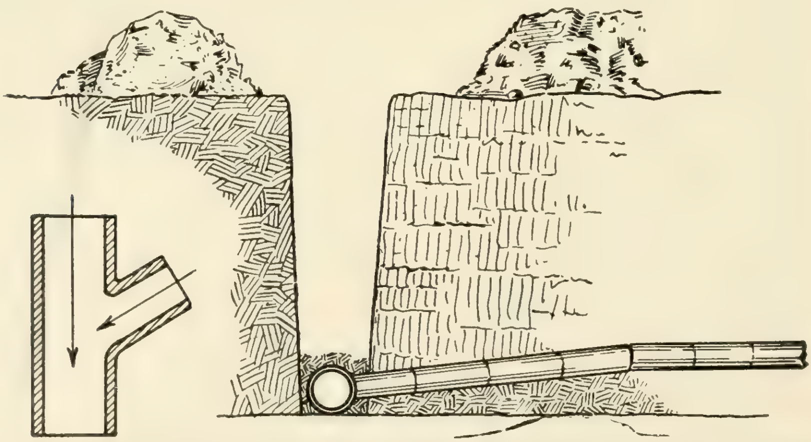



**A shows improper grading and laying of tile. B shows proper grading and laying of tile.**

Wherever a lateral joins the main drain or where two drains unite, the junction should be made at an acute angle in order to better direct the water toward the outlet. If possible, the lateral should have an increased grade for a few feet back to give additional velocity to the discharge. The correct method is shown in the figure above.

## Size of Tile.

A long drain will carry less water than a shorter drain of the same diameter because of the additional friction encountered. The carrying capacity of the drain is also dependent upon the grade or fall, hence the steeper the grade the smaller the tile that may be used. If we in-



**Laterals should join the main drain at an acute angle and with a slightly increased grade for a few feet.**

crease the grade from two inches to four inches per hundred feet we increase the capacity of the drain one-third.

With a reasonable grade, a three-inch tile will drain five acres if the length of the drain is not more than one thousand feet.

Under the same conditions—

A four-inch tile will drain twelve acres.

A five-inch tile will drain twenty acres.

A six-inch tile will drain forty acres.

These figures refer to the main drain. The lateral branches must be proportional to the main drain. In considering this matter it must be remembered that capacities of tile laid upon the same grade are to each other as the squares of their diameters. For example, the capacity of a two-inch tile is to the capacity of a four-inch tile as four to sixteen, or, in other words, the four-inch tile has four times the capacity of a two-inch.

### Depth and Distance Apart of Tile.

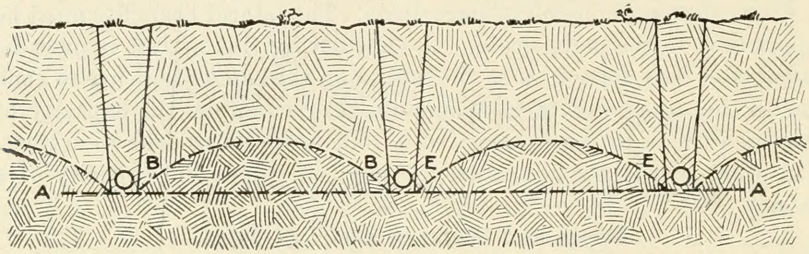
The depth of the drain is so intimately connected with the distance between the lines of tile, that it is impossible to fix on the one without taking into consideration the other. In general, it may be said that a tile four feet deep is considered deep drainage, two and a half to three feet medium, and two feet shallow drainage. Deep drainage should be practiced wherever the soil conditions will permit. Many have the mistaken idea that the removal of surface water is the sole object of drainage, and lose sight of the benefits which deep drainage brings in the way of increased depth of soil and deeper root penetration.

In order to arrive at an intelligent decision as to the proper depth and distance apart of tile drains, it is necessary to understand the fundamental principles connected with the movement of soil water, as discussed in the first part of this bulletin.

In loam soils the drains may be placed deeper and farther apart than in retentive clay soils.

In the following figure, the line BB represents the position of the water table shortly after a heavy rain. If the soil is fairly open, the surface of the ground water will soon take the position AA. This condition will be reached much sooner in an open loam soil than in a retentive clay. Because of the resistance which the soil offers to the movement of the water to the drains, the water table in tenaceous clay lands will hold the position BB for some time. At a point midway between the drains the water will stand near the surface if the lines of tile are too far apart, and the field will be only partially drained. If the drains are placed nearer together, the water table will be lowered more rapidly at the point midway between the lines of tile, and the soil will be more promptly and thoroughly relieved of its surplus water.

For ordinary loam soils the drains may be one hundred feet apart and three and one-half feet deep, but for retentive clay land the depth may have to be reduced to thirty inches and the distance apart to fifty feet. In case of doubt as to the distance apart, it is well to provide drains every one hundred feet and if these are found inadequate, additional lines may be placed midway between.




**A section through a tile-drained soil. BB, the surface of the ground water soon after a heavy rain, and AA, the position of the ground water some days later.**

The following table gives the approximate number of feet of tile which will be required per acre, when laid in parallel lines:

| | |
|---|---|
| 20 feet apart | 2205 feet |
| 30 feet apart | 1470 feet |
| 40 feet apart | 1102 feet |
| 50 feet apart | 880 feet |
| 100 feet apart | 440 feet |

This does not include the intercepting drain which may be necessary in some cases to complete the system.

### The Selection of Tile.

The tile should be well burned and hard enough to give a clear ring when struck with a shovel or a piece of metal. They should be circular in shape and uniform in size so as to make a smooth joint. It is not necessary that the tile should be porous, since the water enters the system through the space at the joints and not through the walls of the tile.

Ordinary unglazed tile when exposed to the weather are chipped and injured by freezing and thawing, hence the last few feet of the system should be of glazed tile or iron sewer pipe. The outlet should be further protected from injury by embedding the last joint in a concrete wall or in stone laid up in cement mortar.

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### Questions.

1. Name the different ways in which soil is benefited by drainage.
2. Why will crops on a well drained soil suffer less from drought than those growing on poorly drained land?

3. For the best growth of crops, how much of the space between the soil particles should be occupied by water?
4. What are the two conditions of land in Ohio that require drainage?
5. What is the effect of tile drains upon the standing water in the soil?
6. What are the first steps in the construction of a drainage system?
7. Describe three general plans upon which a drainage system may be constructed.
8. A drainage ditch 1200 feet long has a total fall of four feet. What is the grade?
9. Make a sketch of the correct method of joining the laterals to the main tile.
10. How many acres will a three-inch tile drain? A six-inch tile?
11. What is the proper depth and distance apart for tile?
12. When placed fifty feet apart, how many feet of tile are required
13. What are the essentials of good tile?

### References for the Teacher.

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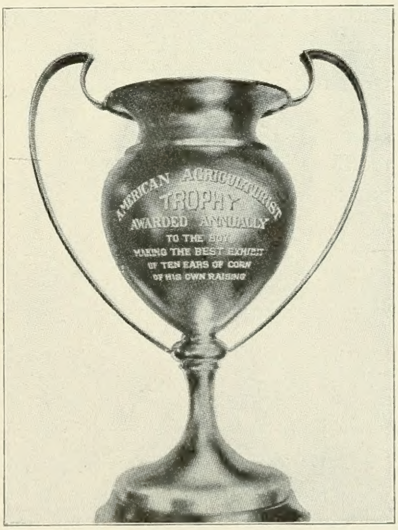
Engineering for Land Drainage.—Elliott. } New York.
First Principles of Soil Fertility.—Vivian; Orange Judd Co., New York.
Farmers' Bulletin No. 187, U. S. Dept. of Agriculture, Washington.
Wisconsin Bulletin No. 146, Wisconsin Experiment Station, Madison.

### Corn Contest Trophies.

**The College of Agriculture Trophy,**
Now held by Morgan Township High School, Okeana, Butler County.
Awarded annually to the High School making the best ten-ear exhibit by each of three students.




**The American Agriculturist Trophy,**
Now Held by Byron Hawley, Woodstock, Ohio.
Awarded annually to the boy making the best exhibit of ten ears of corn of his own raising.

These cups will be awarded at the State Corn Show to be held at Springfield, January 17, 18, 19, 1912.

# When the Christmas Bells are Ringing.

May be used as Solo and Chorus.

BIRDIE BELL. I. H. MEREDITH.


From a complete service for Christmas entitled "Prince Emanuel." Used by permission of Tullar-Meredith Company, New York and Chicago.