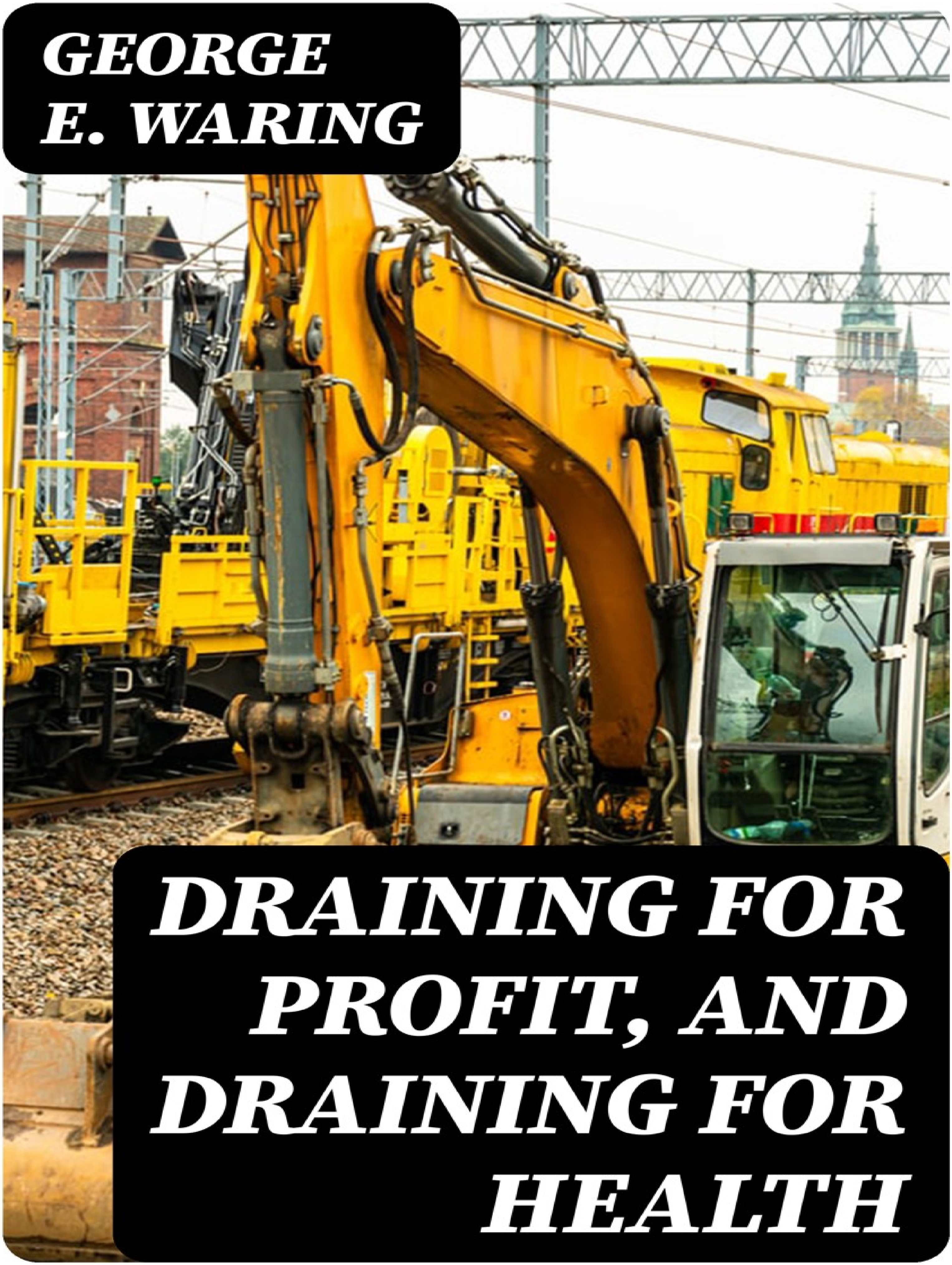
GEORGE E. WARING

DRAINING FOR PROFIT, AND DRAINING FOR HEALTH



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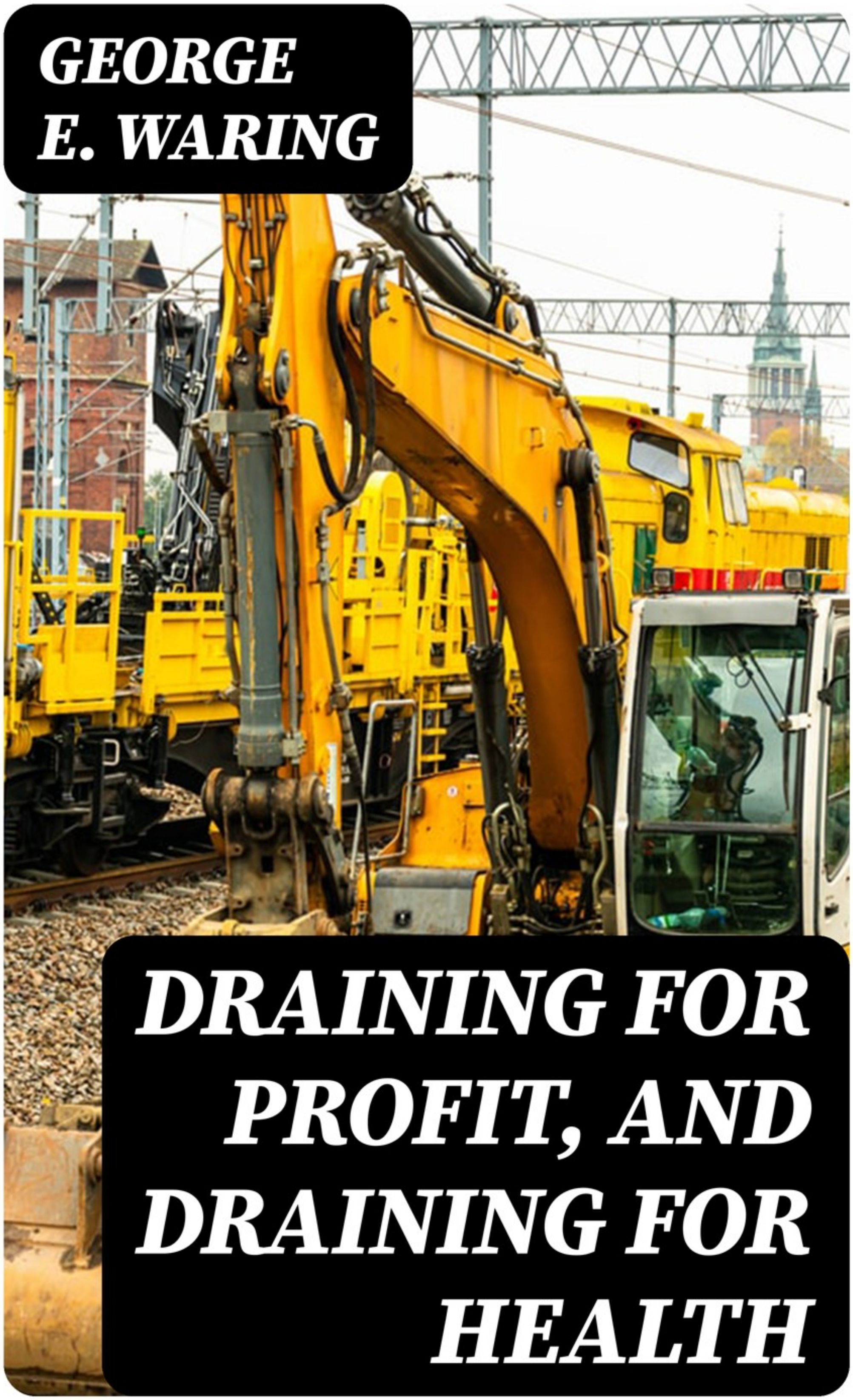

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Contact: DigiCat@okpublishing.info

Table of Contents

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CHAPTER I. - LAND TO BE DRAINED AND THE REASONS WHY.

Table of Contents

Land which requires draining hangs out a sign of its condition, more or less clear, according to its circumstances, but always unmistakable to the practiced eye. Sometimes it is the broad banner of standing water, or dark, wet streaks in plowed land, when all should be dry and of even color; sometimes only a fluttering rag of distress in curling corn, or wide-cracking clay, or feeble, spindling, shivering grain, which has survived a precarious winter, on the ice-stilts that have stretched its crown above a wet soil; sometimes the quarantine flag of rank growth and dank miasmatic fogs.

To recognize these indications is the first office of the drainer; the second, to remove the causes from which they arise.

If a rule could be adopted which would cover the varied circumstances of different soils, it would be somewhat as follows: All lands, of whatever texture or kind, in which *the spaces between the particles of soil* are filled with water, (whether from rain or from springs,) within less than four feet of the surface of the ground, except during and *immediately* after heavy rains, require draining.

Of course, the *particles* of the soil cannot be made dry, nor should they be; but, although they should be moist themselves, they should be surrounded with air, not with water. To illustrate this: suppose that water be poured into a barrel filled with chips of wood until it runs over at the top. The spaces between the chips will be filled with[pg 008] water, and the chips themselves will absorb enough to become thoroughly wet;—this represents the worst condition of a wet soil. If an opening be made at the bottom of the barrel, the water which fills the spaces between the chips will be drawn off, and its place will be taken by air, while the chips themselves will remain wet from the water which they hold by absorption. A drain at the bottom of a wet field draws away the water from the free spaces between its particles, and its place is taken by air, while the particles hold, by attraction, the moisture necessary to a healthy condition of the soil.

There are vast areas of land in this country which do not need draining. The whole range of sands, gravels, light loams and moulds allow water to pass freely through them, and are sufficiently drained by nature, *provided*, they are as open at the bottom as throughout the mass. A sieve filled with gravel will drain perfectly; a basin filled with the same gravel will not drain at all. More than this, a sieve filled with the stiffest clay, if not "puddled,"[1] will drain completely, and so will heavy clay soils on porous and well drained subsoils. Money expended in draining such lands as do not require the operation is, of course, wasted; and when there is doubt as to the requirement,[pg 009] tests should be made before the outlay for so costly work is encountered.

There is, on the other hand, much land which only by thorough-draining can be rendered profitable for cultivation, or healthful for residence, and very much more, described as "ordinarily dry land," which draining would greatly improve in both productive value and salubrity.

The Surface Indications of the necessity for draining are various. Those of actual swamps need no description; those of land in cultivation are more or less evident at different seasons, and require more or less care in their examination, according to the circumstances under which they are manifested.

If a plowed field show, over a part or the whole of its surface, a constant appearance of dampness, indicating that, as fast as water is dried out from its upper parts, more is forced up from below, so that after a rain it is much longer than other lands in assuming the light color of dry earth, it unmistakably needs draining.

A pit, sunk to the depth of three or four feet in the earth, may collect water at its bottom, shortly after a rain;—this is a sure sign of the need of draining.

All tests of the condition of land as to water,—such as trial pits, etc.,—should be made, when practicable, during the wet spring weather, or at a time when the springs and brooks are running full. If there be much water in the soil, even at such times, it needs draining.

If the water of heavy rains stands for some time on the surface, or if water collects in the furrow while plowing, draining is necessary to bring the land to its full fertility.

Other indications may be observed in dry weather;—wide cracks in the soil are caused by the drying of clays, which, by previous soaking, have been pasted together; the curling of corn often indicates that in its early growth it has been prevented, by a wet subsoil, from sending down its roots below the reach of the sun's heat, where it would find,[pg 010] even in the dryest weather, sufficient moisture for a healthy growth; any *severe* effect of drought, except on poor sands and gravels, may be presumed to result from the same cause; and a certain wiryness of grass, together with a mossy or mouldy appearance of the ground, also indicate excessive moisture during some period of growth. The effects of drought are, of course, sometimes manifested on soils which do not require draining,—such as those poor gravels, which, from sheer poverty, do not enable plants to form vigorous and penetrating roots; but any soil of ordinary richness, which contains a fair amount of clay, will withstand even a severe drought, without great injury to its crop, if it is thoroughly drained, and is kept loose at its surface.

Poor crops are, when the cultivation of the soil is reasonably good, caused either by inherent poverty of the land, or by too great moisture during the season of early growth. Which of these causes has operated in a particular case may be easily known. Manure will correct the difficulty in the former case, but in the latter there is no real remedy short of such a system of drainage as will thoroughly relieve the soil of its surplus water.

The Sources of the Water in the soil are various. Either it falls directly upon the land as rain; rises into it from underlying springs; or reaches it through, or over, adjacent land.

The *rain water* belongs to the field on which it falls, and it would be an advantage if it could all be made to pass down through the first three or four feet of the soil, and be removed from below. Every drop of it is freighted with fertilizing matters washed out from the air, and in its descent through the ground, these are given up for the use of plants; and it performs other important work among the vegetable and mineral parts of the soil.

The *spring water* does not belong to the field,—not a[pg 011] drop of it,—and it ought not to be allowed to show itself within the reach of the roots of ordinary plants. It has fallen on other land, and, presumably, has there done its appointed work, and ought not to be allowed to convert our soil into a mere outlet passage for its removal.

The *ooze water*,—that which soaks out from adjoining land,—is subject to all the objections which hold against spring water, and should be rigidly excluded.

But the *surface water* which comes over the surface of higher ground in the vicinity, should be allowed every opportunity, which is consistent with good husbandry, to work its slow course over our soil,—not to run in such streams as will cut away the surface, nor in such quantities as to make the ground inconveniently wet, but to spread itself in beneficent irrigation, and to deposit the fertilizing matters which it contains, then to descend through a well-drained subsoil, to a free outlet.

From whatever source the water comes, it cannot remain stagnant in any soil without permanent injury to its fertility.

The Objection to too much Water in the Soil will be understood from the following explanation of the process of germination, (sprouting,) and growth. Other grave reasons why it is injurious will be treated in their proper order.

The first growth of the embryo plant, (in the seed,) is merely a change of form and position of the material which the seed itself contains. It requires none of the elements of the soil, and would, under the same conditions, take place as well in moist saw-dust as in the richest mold. The conditions required are, the exclusion of light; a certain degree of heat; and the presence of atmospheric air, and moisture. Any material which, without entirely excluding the air, will shade the seed from the light, yield the necessary amount of moisture, and allow the accumulation of the requisite heat, will favor the chemical[pg 012] changes which, under these circumstances, take place in the living seed. In proportion as the heat is reduced by the chilling effect of evaporation, and as atmospheric air is excluded, will the germination of the seed be retarded; and, in case of complete saturation for a long time, absolute decay will ensue, and the germ will die.

The accompanying illustrations, (Figures 1, 2 and 3,) from the "Minutes of Information" on Drainage, submitted by the General Board of Health to the British Parliament in 1852, represent the different conditions of the soil as to moisture, and the effect of these conditions on the germination of seeds. The figures are thus explained by Dr. Madden, from whose lecture they are taken:

> "Soil, examined mechanically, is found to consist entirely of particles of all shapes and sizes, from stones and pebbles down to the finest powder; and, on account of their extreme irregularity of shape, they cannot lie so close to one another as to prevent there being passages between them, owing to which circumstance soil in the mass is always more or less *porous*. If, however, we proceed to examine one of the smallest particles of which soil is made up, we shall find that even this is not always solid, but is much more frequently porous, like soil in the mass. A considerable proportion of this finely-divided part of soil, *the impalpable matter*, as it is generally called, is found, by the aid of the microscope, to consist of *broken down vegetable tissue*, so that when a small portion of the finest dust from a garden or field is placed under the microscope, we have exhibited to us

particles of every variety of shape and structure, of which a certain part is evidently of vegetable origin.

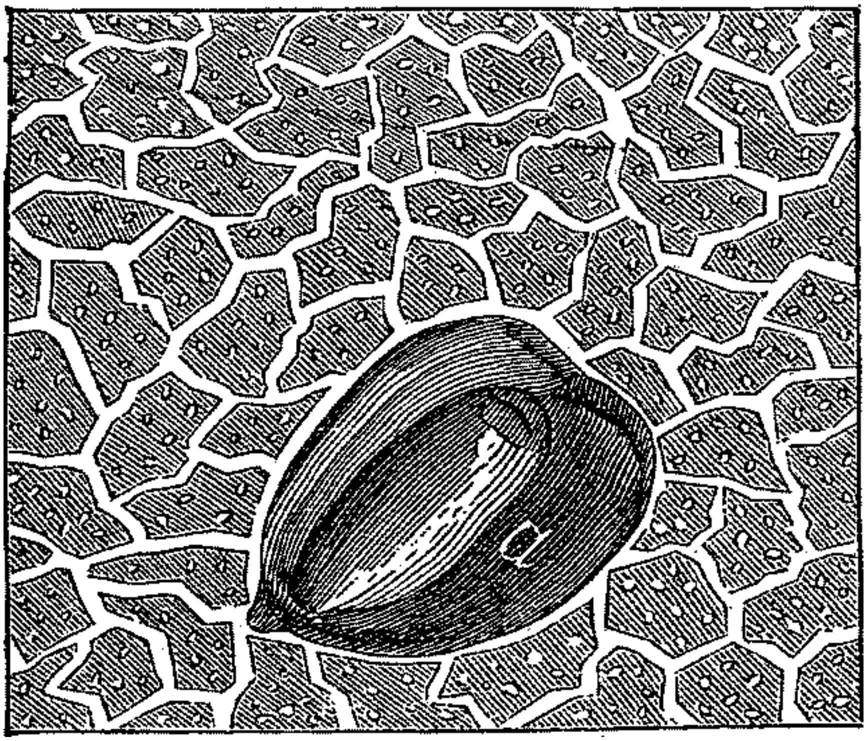

Fig. 1 - A DRY SOIL.

"In these figures I have given a very rude representation of these particles; and I must beg you particularly to remember that they are not meant to represent by any means accurately what the microscope exhibits, but are[pg 013] only designed to serve as a plan by which to illustrate the mechanical properties of the soil. On referring to Fig. 1, we perceive that there are two distinct classes of pores,—first, the large ones, which exist *between* the particles of soil, and second, the very minute ones, which occur in the particles themselves; and you will at the same time notice that, whereas all the larger pores,—those between the particles of soil,—communicate most freely with each other, so that they form canals, the small pores, however freely they may communicate with one another in the interior of the particle in which they occur, have no direct connection with the pores of the surrounding particles. Let us now, therefore, trace the effect of this arrangement. In Fig. 1 we perceive that these canals and pores are all empty, the soil being *perfectly dry*; and the canals communicating freely at the surface with the surrounding atmosphere, the whole will of course be filled with air. If in this condition a seed be placed in the soil, at *a*, you at once perceive that it is freely supplied with air, *but there is no moisture*; therefore, when soil is *perfectly dry*, a seed cannot grow.

Fig. 2 - A WET SOIL.

"Let us turn our attention now to Fig. 2. Here we[pg 014] perceive that both the pores and canals are no longer represented white, but black, this color being used to indicate water; in this instance, therefore, water has taken the place of air, or, in other words, the soil is *very wet*. If we observe our seed *a* now, we find it abundantly supplied with water, but *no air*. Here again, therefore, germination cannot take place. It may be well to state here that this can never occur *exactly* in nature, because, water having the power of dissolving air to a certain extent, the seed *a* in Fig. 2 is, in fact, supplied with a *certain* amount of this necessary substance; and, owing to this, germination does take place, although by no means under such advantageous circumstances as it would were the soil in a better condition.

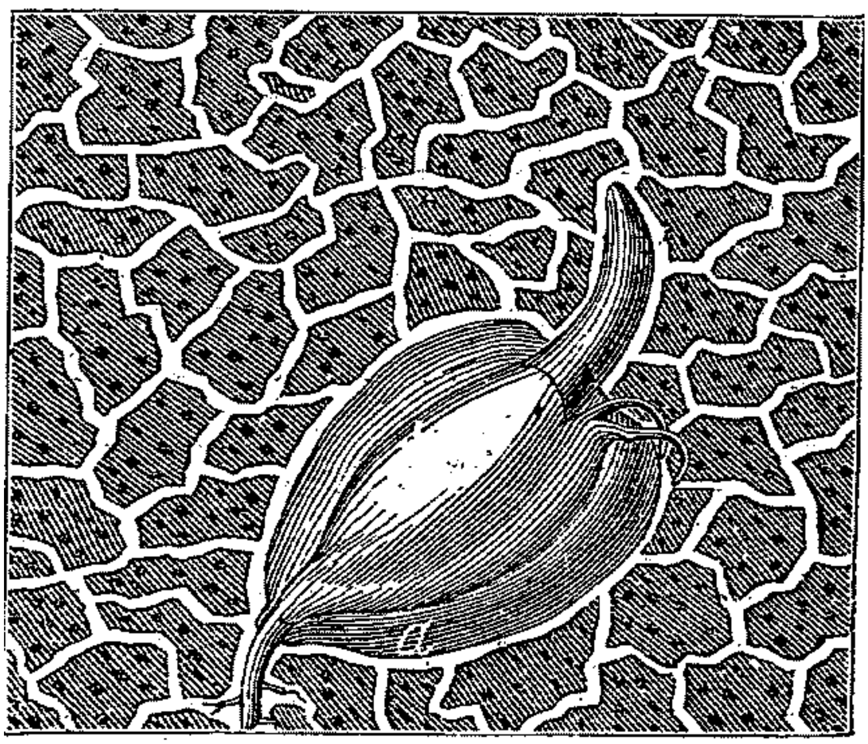

Fig. 3 - A DRAINED SOIL.

"We pass on now to Fig. 3. Here we find a different state of matters. The canals are open and freely supplied with air,

> while the pores are filled with water; and, consequently, you perceive that, while the seed *a* has quite enough of air from the canals, it can never be without moisture, as every particle of soil which touches it is well supplied with this necessary ingredient. This, then, is the proper condition of soil for germination, and in fact for every period of the plant's development; and this condition occurs when the soil is *moist*, but not *wet*,—that is to say, when it has the color and appearance of being well watered, but when it is still capable of being crumbled to pieces by the hands, without any of its particles adhering together in the familiar form of mud."

As plants grow under the same conditions, as to soil, that are necessary for the germination of seeds, the foregoing explanation of the relation of water to the particles of the soil is perfectly applicable to the whole period of vegetable growth. The soil, to the entire depth occupied by roots, which, with most cultivated plants is, in drained land, from two to four feet, or even more, should be maintained, as nearly as possible, in the condition represented in Fig. 3,—that is, the particles of soil should hold water by attraction, (absorption,) and the spaces between the particles should be filled with air. Soils which require drainage are not in this condition. When they are not saturated with water, they are generally dried into lumps and clods, which are almost as impenetrable by roots as so many stones. The moisture which these clods contain is not available to plants, and their surfaces are liable to be dried by the too free circulation of air among the wide fissures between them. It is also worthy of incidental remark, that the cracking of heavy soils, shrinking by drought, is attended by the tearing asunder of the smaller roots which may have penetrated them.

The Injurious Effects of Standing Water in the Subsoil may be best explained in connection with the description of a soil which needs under-draining. It would be tedious, and superfluous, to attempt to detail the various geological formations and conditions which make the soil unprofitably wet, and render draining necessary. Nor,—as this work is intended as a hand-book for practical use,—is it deemed advisable to introduce the geological charts and sections, which are so often employed to illustrate the various sources of under-ground water; interesting as they are to students of the theories of agriculture, and important as the study is, their consideration here would consume space, which it is desired to devote only to the reasons for, and the practice of, thorough-draining.

[pg 016]

To one writing in advocacy of improvements, of any kind, there is always a temptation to throw a tub to the popular whale, and to suggest some make-shift, by which a certain advantage may be obtained at half-price. It is proposed in this essay to resist that temptation, and to adhere to the rule that "whatever is worth doing, is worth doing well," in the belief that this rule applies in no other department of industry with more force than in the draining of land, whether for agricultural or for sanitary improvement. Therefore, it will not be recommended that draining be ever confined to the wettest lands only; that, in the pursuance of a penny-wisdom, drains be constructed with stones, or brush, or boards; that the antiquated horse-shoe tiles be used, because they cost less money; or that it will, in any case, be economical to make only such drains as are necessary to remove the water of large springs. The doctrine herein advanced is, that, so far as draining is applied at all, it should be done in the most thorough and complete manner, and that it is better that, in commencing this improvement, a single field be really well drained, than that the whole farm be half drained.

Of course, there are some farms which suffer from too much water, which are not worth draining at present; many more which, at the present price of frontier lands, are only worth relieving of the water which stands on the surface; and not a few on which the quantity of stone to be removed suggests the propriety of making wide ditches, in which to hide them, (using the ditches, incidentally, as drains). A hand-book of draining is not needed by the owners of these farms; their operations are simple, and they require no especial instruction for their performance. This work is addressed especially to those who occupy lands of sufficient value, from their proximity to market, to make it cheaper to cultivate well, than to buy more land for the sake of getting a larger return from poor cultivation.[pg 017] Wherever Indian corn is worth fifty cents a bushel, on the farm, it will pay to thoroughly drain every acre of land which needs draining. If, from want of capital, this cannot be done at once, it is best to first drain a portion of the farm, doing the work thoroughly well, and to apply the return from the improvement to its extension over other portions afterward.

In pursuance of the foregoing declaration of principles, it is left to the sagacity of the individual operator, to decide when the full effect desired can be obtained, on particular lands, without applying the regular system of depth and distance, which has been found sufficient for the worst cases. The directions of this book will be confined to the treatment of land which demands thorough work.

Such land is that which, at some time during the period of vegetation, contains stagnant water, at least in its sub-soil, within the reach of the roots of ordinary crops; in which there is not a free outlet *at the bottom* for all the water which it receives from the heavens, from adjoining land, or from springs; and which is more or less in the condition of standing in a great, water-tight box, with openings to let water in, but with no means for its escape, except by evaporation at the surface; or, having larger inlets than outlets, and being at times "water-logged," at least in its lower parts. The subsoil, to a great extent, consists of clay or other compact material, which is not *impervious*, in the sense in which india-rubber is impervious, (else it could not have become wet,) but which is sufficiently so to prevent the free escape of water. The surface soil is of a lighter or more open character, in consequence of the cultivation which it has received, or of the decayed vegetable matter and the roots which it contains.

In such land the subsoil is wet,—almost constantly wet,—and the falling rain, finding only the surface soil in a condition to receive it, soon fills this, and often more than fills it, and stands on the surface. After the rain, come wind and[pg 018] sun, to dry off the standing water,—to dry out the free water in the surface soil, and to drink up the water of the subsoil, which is slowly drawn from below. If no spring, or ooze, keep up the supply, and if no more rain fall, the subsoil may be dried to a considerable depth, cracking and gaping open, in wide fissures, as the clay loses its water of absorption, and shrinks. After the surface soil has become sufficiently dry, the land may be plowed, seeds will germinate, and plants will grow. If there be not too much rain during the season, nor too little, the crop may be a fair one,—if the land be rich, a very good one. It is not impossible, nor even very uncommon, for such soils to produce largely, but they are always precarious. To the labor and expense of cultivation, which fairly earn a secure return, there is added the anxiety of chance; success is greatly dependent on the weather, and the weather may be bad: Heavy rains, after planting, may cause the seed to rot in the ground, or to germinate imperfectly; heavy rains during early growth may give an unnatural development, or a feeble character to the plants; later in the season, the want of sufficient rain may cause the crop to be parched by drought, for its roots, disliking the clammy subsoil below, will have extended within only a few inches of the surface, and are subject, almost, to the direct action of the sun's heat; in harvest time, bad weather may delay the gathering until the crop is greatly injured, and fall and spring work must often be put off because of wet.

The above is no fancy sketch. Every farmer who cultivates a retentive soil will confess, that all of these inconveniences conspire, in the same season, to lessen his returns, with very damaging frequency; and nothing is more common than for him to qualify his calculations with the proviso, "if I have a good season." He prepares his ground, plants his seed, cultivates the crop, "does his best,"—thinks he does his best, that is,—and trusts to Providence to send him good weather. Such farming is attended with[pg 019] too much uncertainty,—with too much *luck*,—to be satisfactory; yet, so long as the soil remains in its undrained condition, the element of luck will continue to play a very important part in its cultivation, and bad luck will often play sad havoc with the year's accounts.

Land of this character is usually kept in grass, as long as it will bring paying crops, and is, not unfrequently, only available for pasture; but, both for hay and for pasture, it is still subject to the drawback of the uncertainty of the seasons, and in the best seasons it produces far less than it might if well drained.

The effect of this condition of the soil on the health of animals living on it, and on the health of persons living near it, is extremely unfavorable; the discussion of this branch of the question, however, is postponed to a later chapter.

Thus far, there have been considered only the *effects* of the undue moisture in the soil. The manner in which these effects are produced will be examined, in connection with the manner in which draining overcomes them,—reducing to the lowest possible proportion, that uncertainty which always attaches to human enterprises, and which is falsely supposed to belong especially to the cultivation of the soil.

Why is it that the farmer believes, why should any one believe, in these modern days, when the advancement of science has so simplified the industrial processes of the world, and thrown its light into so many corners, that the word "mystery" is hardly to be applied to any operation of nature, save to that which depends on the always mysterious Principle of Life,—when the effect of any combination of physical circumstances may be foretold, with almost unerring certainty,—why should we believe that the success of farming must, after all, depend mainly on chance? That an intelligent man should submit the success of his own patient efforts to the operation of "luck;" that he should deliberately *bet* his capital, his toil,[pg 020] and his experience on having a good season, or a bad one,—this is not the least of the remaining mysteries. Some chance there must be in all things,—more in farming than in mechanics, no doubt; but it should be made to take the smallest possible place in our calculations, by a careful avoidance of every condition which may place our crops at the mercy of that most uncertain of all things—the weather; and especially should this be the case, when the very means for lessening the element of chance in our calculations are the best means for increasing our crops, even in the most favorable weather.

[pg 021]

CHAPTER II. - HOW DRAINS ACT, AND HOW THEY AFFECT THE SOIL

Table of Contents

For reasons which will appear, in the course of this work, the only sort of drain to which reference is here made is that which consists of a conduit of burned clay, (tile,) placed at a considerable depth in the subsoil, and enclosed in a compacted bed of the stiffest earth which can conveniently be found. Stone-drains, brush-drains, sod-drains, mole-plow tracks, and the various other devices for forming a conduit for the conveying away of the soakage-water of the land, are not without the support of such arguments as are based on the expediency of make-shifts, and are, perhaps, in rare cases, advisable to be used; but, for the purposes of permanent improvement, they are neither so good nor so economical as tile-drains. The arguments of this book have reference to the latter, (as the most perfect of all drains thus far invented,) though they will apply, in a modified degree, to all underground conduits, so long as they remain free from obstructions. Concerning stone-drains, attention may properly be called to the fact that, (contrary to the general opinion of farmers,) they are very much more expensive than tile-drains. So great is the cost of cutting the ditches to the much greater size required for stone than for tiles, of handling the stones, of placing them properly in the ditches, and of covering them, after they are laid, with a suitable barrier to the rattling down of loose earth among them, that, as a mere question of first cost, it is far cheaper to buy tiles than to use stones, although these may lie on the surface[pg 022] of the field, and only require to be placed in the trenches. In addition to this, the great liability of stone-drains to become obstructed in a few years, and the certainty that tile-drains will, practically, last forever, are conclusive arguments in favor of the use of the latter. If the land is stony, it must be cleared; this is a proposition by itself, but if the sole object is to make drains, the best material should be used, and this material is not stone.

A well laid tile-drain has the following essential characteristics:—1. It has a free outlet for the discharge of all water which may run through it. 2. It has openings, at its joints, sufficient for the admission of all the water which may rise to the level of its floor. 3. Its floor is laid on a well regulated line of descent, so that its current may maintain a flow of uniform, or, at least, never decreasing rapidity, throughout its entire length.

Land which requires draining, is that which, at some time during the year, (either from an accumulation of the rains which fall upon it, from the lateral flow, or soakage, from adjoining land, from springs which open within it, or from a combination of two or all of these sources,) becomes filled with water, that does not readily find a natural outlet, but remains until removed by evaporation. Every considerable addition to its water wells up, and soaks its very surface; and that which is added after it is already brim full, must flow off over the surface, or lie in puddles upon it. Evaporation is a slow process, and it becomes more and more slow as the level of the water recedes from the surface, and is sheltered, by the overlying earth, from the action of sun and wind. Therefore, at least during the periods of spring and fall preparation of the land, during the early growth of plants, and often even in midsummer, the *water-table*,—the top of the water of saturation,—is within a few inches of the surface, preventing the natural descent of roots, and, by reason of the small space to receive[pg 023] fresh rains, causing an interruption of work for some days after each storm.

If such land is properly furnished with tile-drains, (having a clear and sufficient outfall, offering sufficient means of entrance to the water which reaches them, and carrying it, by a uniform or increasing descent, to the outlet,) its water will be removed to nearly, or quite, the level of the floor of the drains, and its water-table will be at the distance of some feet from the surface, leaving the spaces between the particles of all of the soil above it filled with air instead of water. The water below the drains stands at a level, like any other water that is dammed up. Rain water falling on the soil will descend by its own weight to this level, and the water will rise into the drains, as it would flow over a dam, until the proper level is again attained. Spring water entering from below, and water oozing from the adjoining land, will be removed in like manner, and the usual condition of the soil, above the water-table, will be that represented in Fig. 3, the condition which is best adapted to the growth of useful plants.

In the heaviest storms, some water will flow over the surface of even the dryest beach-sand; but, in a well drained soil the water of ordinary rains will be at once absorbed, will slowly descend toward the water-table, and will be removed by the drains, so rapidly, even in heavy clays, as to leave the ground fit for cultivation, and in a condition for steady growth, within a short time after the rain ceases. It has been estimated that a drained soil has room between its particles for about one quarter of its bulk of water;—that is, four inches of drained soil contains free space enough to receive a rain-fall one inch in depth, and, by the same token, four feet of drained soil can receive twelve inches of rain,—-more than is known to have ever fallen in twenty-four hours, since the deluge, and more than one quarter of the *annual* rain-fall in the United States.

As was stated in the previous chapter, the water which reaches the soil may be considered under two heads:

1st—That which reaches its surface, whether directly by rain, or by the surface flow of adjoining land.

2d—That which reaches it below the surface, by springs and by soakage from the lower portions of adjoining land.

The first of these is beneficial, because it contains fresh air, carbonic acid, ammonia, nitric acid, and heat, obtained from the atmosphere; and the flowage water contains, in addition, some of the finer or more soluble parts of the land over which it has passed. The second, is only so much dead water, which has already given up, to other soil, all that ours could absorb from it, and its effect is chilling and hurtful. This being the case, the only interest we can have in it, is to keep it down from the surface, and remove it as rapidly as possible.

The water of the first sort, on the other hand, should be arrested by every device within our reach. If the land is steep, the furrows in plowing should be run horizontally along the hill, to prevent the escape of the water over the surface, and to allow it to descend readily into the ground. Steep grass lands may have frequent, small, horizontal ditches for the same purpose. If the soil is at all heavy, it should not, when wet, be trampled by animals, lest it be puddled, and thus made less absorptive. If in cultivation, the surface should be kept loose and open, ready to receive all of the rain and irrigation water that reaches it.

In descending through the soil, this water, in summer, gives up heat which it received from the air and from the heated surface of the ground, and thus raises the temperature of the lower soil. The fertilizing matters which it has obtained from the air,—carbonic acid, ammonia and nitric acid,—are extracted from it, and held for the use of growing plants. Its fresh air, and the air which follows the descent of the water-table, carries oxygen to the organic and[pg 025] mineral parts of the soil, and hastens the rust and decay by which these are prepared for the uses of vegetation. The water itself supplies, by means of their power of absorption, the moisture which is needed by the particles of the soil; and, having performed its work, it goes down to the level of the water below, and, swelling the tide above the brink of the dam, sets the drains running, until it is all removed. In its descent through the ground, this water clears the passages through which it flows, leaving a better channel for the water of future rains, so that, in time, the heaviest clays, which will drain but imperfectly during the first one or two years, will pass water, to a depth of four or five feet, almost as readily as the lighter loams.

Now, imagine the drains to be closed up, leaving no outlet for the water, save at the surface. This amounts to a raising of the dam to that height, and additions to the water will bring the water-table even with the top of the soil. No provision being made for the removal of spring and soakage water, this causes serious inconvenience, and even the rain-fall, finding no room in the soil for its reception, can only lie upon, or flow over, the surface,—not yielding to the soil the fertilizing matters which it contains, but, on the contrary, washing away some of its finer and looser parts. The particles of the soil, instead of being furnished, by absorption, with a healthful amount of moisture, are made unduly wet; and the spaces between them, being filled with water, no air can enter, whereby the chemical processes by which the inert minerals, and the roots and manure, in the soil are prepared for the use of vegetation, are greatly retarded.

Instead of carrying the heat of the air, and of the surface of the ground, to the subsoil, the rain only adds so much to the amount of water to be evaporated, and increases, by so much, the chilling effect of evaporation.

Instead of opening the spaces of the soil for the more free passage of water and air, as is done by descending water, that which ascends by evaporation at the surface brings up soluble matters, which it leaves at the point where it becomes a vapor, forming a crust that prevents the free entrance of air at those times when the soil is dry enough to afford it space for circulation.

Instead of crumbling to the fine condition of a loam, as it does, when well drained, by the descent of water through it, heavy clay soil, being rapidly dried by evaporation, shrinks into hard masses, separated by wide cracks.

In short, in wet seasons, on such land, the crops will be greatly lessened, or entirely destroyed, and in dry seasons, cultivation will always be much more laborious, more hurried, and less complete, than if it were well drained.

The foregoing general statements, concerning the action of water in drained, and in undrained land, and of the effects of its removal, by gravitation, and by evaporation, are based on facts which have been developed by long practice, and on a rational application of well know principles of science. These facts and principles are worthy of examination, and they are set forth below, somewhat at length, especially with reference to *Absorption* and