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SUGGESTIONS REGARDING THE EXAMINATION OF LANDS

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The frequency with which this Station is called upon to give advice in regard to soils, whether in respect to the quality and best adaptations of new lands, or the correction of faults observed in those already under cultivation, renders it desirable to formulate some general explanations on the subject, which may in many cases enable the farmer to come to a definite forecast or conclusion, without individual consultation and advice; or, when this is not attainable, may so instruct him that he can forward to the Station such definite statements of facts, and samples properly taken, as will convey the data needful for a full understanding of the situation.

Very many conditions contribute toward the agricultural characteristics of a soil, and any one or more of these may, under certain circumstances, be the controlling one. It is therefore essential that the information given by the farmer should be as complete as possible, since without it the trouble involved in the examination of samples will as a rule not be justified, as lacking the proper basis for an intelligent opinion or fruitful advice.

Not many years ago it was the custom to ascribe the languishing or death of trees and crops to some "poison" contained or generated in the soil. In California, the poison theory still maintains itself to some extent, in ascribing the trouble observed to "alkali," even though no manifestations of that substance may ever appear on the surface. But unless a soil at the end of the dry season shows a white crust or dust of alkali salts on the surface, there is no reason whatever to suppose that alkali has anything to do, directly, with injury to the crop or trees; for such injury is rarely done to the roots *in* the soil, but usually by the accumulation of alkali salts near the surface.

Leaving aside the case of special diseases, such as are due to the action of fungi, insects, or other organisms, it has now become usual, in this State at least, to attribute any faulty or defective growth of culture plants to some chemical defect in the soil, and to address to the Station the question what fertilizer should be used to make up the deficiency.

Extended investigation of our soils has shown that in California, far more than in the Eastern States, very few soil-materials exist that would not naturally produce good crops for some 18 or 20 years without fertilization, provided they are of sufficient depth and are adequately supplied with moisture. In many cases, forty or fifty years is a low estimate for the duration of profitable production. When, therefore, in orchard or vineyard, it is noticed that after growing well from three to five years, or even longer, the trees or vines begin to languish, and sometimes even to die, it is not as a rule reasonable to conclude that it is for want of any needful ingredient in the soil. This is especially true of the "die-back" in orchards—the dying of the tips of branches in the tree-tops, which, when not clearly due to scale insects or fungous attack, is nearly always caused by some defect in the subsoil, at or near the ends of the roots; such as hardpan, dry gravel layers, bottom water, or the like. Such defects cannot, of course, be cured by fertilization; and the farmer himself can, by the exercise of common sense and digging to the ends of the roots, satisfy himself very quickly of the existence or absence of such defects, which can often not be recognized when samples are sent to the Station, but must be observed on the spot.

Importance of the Subsoil.—In our dry climate, *depth* of the soil is of the first importance, since the roots of culture plants must go deep in order to be secure against the summer's drought. As the latter renders the surface soil, which in the humid region is the main source of supply to plants, practically unavailable during a large part of the season of growth, it is clear that here, more than anywhere, the *depth and qaulity of the subsoil* is of the greatest importance, and should be investigated in all cases by the intending purchaser of land before investing. The omission of this simple precaution has led to untold losses and disappointments, which have been the more frequent as the formation of a "hardpan" at a depth corresponding more or less to the penetration of the annual rainfall, is of unusually frequent occurrence in this State. The richest surface soil may be utterly useless for general farming purposes if underlaid, at a depth varying, according to the nature of the soil, from one to four feet, by a hardpan or clay impervious to the roots of plants. As a rule it is not practically feasible to maintain, even by irrigation, a proper supply of moisture in a light soil limited in depth by impervious hardpan at two or three feet, even in cases where the roots of the crop do not habitually penetrate beyond that depth; in the case of fruit trees and vines (the roots of which in certain lands are limited only by a depth beyond fifteen or twenty feet) the objection to such lands in their natural condition is insuperable, unless the difficulty can be overcome by dynamiting the tree-holes.

An equally fatal objection, so far as tree culture is concerned, lies against too close proximity of bottom water to the surface. The roots of culture plants will bear submergence only for a very limited time without injury (forty days is considered the extreme limit in the case of vines and orchard trees); hence lands periodically overflowed and not very perfectly drained are unsafe for the planting of trees, as the roots will decay where the air is excluded; and such injured roots will inevitably render the tree unproductive, if they do not kill it in the course of time. The same effects are of course produced wherever leaky irrigation ditches cause the rise of water to within a few feet of the surface. *Drainage,* not fertilization, is the effective remedy in such cases. Yet such lands may be well adapted to the growth of certain shallow-rooted crops, particularly of those having a short period of growth.

On the other hand, in some kinds of sandy lands, the breaking up of what might be considered a hardpan, as compared with the surface soil, may almost wholly destroy its cultural value by rendering it "leachy," so that neither irrigation water nor fertilizers will be sufficiently retained for the profitable growth of crops. It is therefore clearly necessary that not only the existence of such underground layers be definitely ascertained, but also that their particular nature be considered with respect to the kind of surface soil, and to the practically feasible or profitable uses to which the land is intended to be put.

Examination of the Subsoil.—Outside of adobe tracts, an exceedingly simple and effective device for subsoil examination is a square steel rod not less than a quarter of an inch in diameter, well pointed at one end, and provided at the other with a stout iron ring for the reception of a cross-handle, such as is used for post-hole augers. With such a prod or sounding-rod, not less than five feet in length, and made to penetrate the soil by means of a slight reciprocating motion aided by the weight of the operator, the exploration of the subsoil for hardpan, dense clay layers or bottom water becomes a matter of a few minutes; and a few hours' time suffices to thus explore extended tracts, and perhaps save bad investments of thousands of dollars; or, at the very least, to convey very valuable information as to the probable defects or virtues of the land, not only with respect to root penetration, but also with regard to irrigation, drainage, etc. It is easy also to detect thus, with a little practice, the presence of underlying layers of quicksand, gravel, or other loose materials through which irrigation water would waste, or which would present the capillary rise of bottom moisture within the reach of plant roots, by the large iterspaces between their grains. Any remaining doubts as to the nature of such underlying materials at particular points can then quickly be settled by the use of a post-hole auger. The latter serves also most conveniently for the taking of samples to be submitted for examination by the Station; but it should be remembered that in no case should any one sample represent the average of more than one foot in depth; and that whenever a material change of resistance to the auger's penetration is observed, the depth at which such change occurs should be noted, and a sample taken of the material causing such change, again not to exceed in any case the additional depth of one foot.

The extreme depth to which the boring and taking of samples should reach depends not only upon the nature of the soil, but also upon that of the crop expected to be planted. The tap-root of a pear tree will in almost any soil require, for normal development, a depth of six feet at least; hence pear trees should never be planted in shallow soil. Almonds and peaches, on the other hand, will be content with half that depth, if necessary, provided the soil be rich enough and the supply of moisture adequate, but not excessive.

In coarse, gravelly soils, as well as in hard adobe, it may become necessary to use the pick and spade (not shovel) to dig a vertical hole of sufficient width and depth for observation, and for the taking of samples to be examined. In digging such holes the same rule as above given for the post-hole borings should be observed.

When, after careful examination of the soil and subsoil as described above, doubt remains as to the cause of any difficulty observed, or when for special reasons a more thorough examination of the case is desirable or necessary, samples representing the average of not more than *one foot each* may be taken, from the surface down to such depth as may be thought needful in each case, in accordance with the directions given below, for transmission to the Experiment Station at Berkeley.

Value of Soil Examinations and Analyses.—It is necessary to refer here to some erroneous ideas and prejudices regarding the practical application of the results obtained from soil examination, and from chemical soil analysis especially. While some imagine that such an analysis can, like the assay of a mineral, tell them just what the soil is worth, or what it needs to make it productive, others have, on the contrary, been taught to believe that chemical soil analysis is utterly useless, and can convey no information useful to the farmer. As usual, the truth lies between the two extremes.

The physical (mechanical) and chemical conditions existing in a soil are of equal importance for plant growth; if either be seriously defective the farmer will labor under a great disadvantage. But usually the chemical deficiencies are more readily remedied by fertilization than physical defects, which should, therefore, receive the first investigation and consideration.

But when the physical conditions are found satisfactory, chemical analysis will, in virgin soils, or in such as have been under cultivation only a short time, give most definite and practically useful information as to the means of improvement, if such be necessary. The habit of many Eastern immigrants, of asking how to fertilize, right at first, the exuberantly fertile natural soils of California and of the arid region generally, is a solicitude wholly uncalled for. The farmer cannot, however, make chemical analyses himself; and even if made by a chemist, they may be of little use unless the method employed be known and considered, and the results intelligently interpreted by an expert. This in the case of soils *long* cultivated and fertilized is often a very difficult problem, to be successfully handled only when the cultural history of the soil area in question is known. Hence the disappointments so commonly commented on in the Eastern States and in Europe, where nearly all soils have been artificially changed.

With a knowledge of the composition of a virgin soil and of the crops that have been or are intended to be grown upon it, we are in a position to give to the farmer forecasts of what is most likely to benefit his soil most, with the least expense, and with at least equal probability of correct judgment as in the case of a physician prescribing for a patient. In both cases the practical test is the final one; in both, random experimenting or quacks may hit or miss the mark.

DIRECTIONS FOR TAKING SOIL SAMPLES.

In taking soil specimens for examination by the Agricultural Experiment Station of the University, the following directions should be carefully observed—always bearing in mind that the examination, and especially the analysis, of a soil is a long and tedious operation, which cannot be indefinitely repeated.

First.—When ascertaining the respective merits of new lands, do not take samples at random from any points on the land, but consider what are the two or three chief varieties of soil which, *with their intermixtures,* make up the cultivable or cultivated area, and if necessary, sample these, each separately; then sample the particular soil on which you desire information, noting its relation to these typical ones.

Second.—As a rule take specimens from spots that have not been changed from their original condition of "virgin soils," *e.g.,* not from ground frequently trodden over, such as roadsides, cattle-paths, or small pastures, squirrel holes, stumps, or even the foot of trees, or spots that have been washed by rains or streams, so as to have experienced a notable change, and not be a fair representative of their kind.

Third.—Observe and record carefully the normal vegetation, trees, herbs, grass, etc., of the average virgin land; avoid spots showing unusual growth, whether in kind or in quality, as such are likely to have received some animal manure, or other outside addition.

Fourth.—Always take specimens from more than one spot judged to be a fair representative of the soil intended to be examined, as an additional guarantee of a fair average, and mix thoroughly the earth taken from the same depths.

Fifth.—After selecting a proper spot, pull up the plants growing on it, and sweep off the surface with a broom or brush to remove half-decayed vegetable matter not forming part of the soil as yet. Dig or bore a vertical hole, like a post-hole, removing a foot in depth, and note at what depth a change of tint occurs. In the humid region, or in humid lowlands of the arid, this will usually happen at from six to nine inches from the surface, and a sample taken to that depth will constitute the "soil."

In California and the arid region generally very commonly no change of tint occurs within the *first foot,* sometimes not for several feet; hence, especially in sandy lands, the "soil" sample will usually be taken to that depth, so as to represent the *average* of the first foot from the surface down.

Samples taken merely from the surface, or from the bottom of a hole, have no definite meaning, and will not be examined or reported upon.

Place the soil sample upon a cloth (jute bagging should not be used for the purpose, as its fibers, dust, etc., become intermixed with the soil) or paper, break it up, mix thoroughly, and put *at least a quart* of it in a sack or package properly labeled for examination.

This specimen will, ordinarily, constitute the "soil." Should the change of color occur at a less depth than six inches, the fact should be noted, but the specimen taken to that depth nevertheless, since it is the least to which rational culture can be supposed to reach.

In this way take a sample of each foot separately to a depth of at least three feet; preferably four or five; especially in the case of alkali soils, or suspected hardpan.

Sixth.—Whatever lies beneath the line of change, or below the minimum depth of six inches, will constitute the "subsoil." But should the change of color occur at a greater depth than twelve inches, the "soil" specimen should nevertheless be taken to the depth of twelve inches only, which is the limit of ordinary tillage; then another specimen from that depth down to the line of change, and then the subsoil specimens beneath that line.

The depth down to which the last should be taken will depend on circumstances. It is always necessary to know what constitutes the foundation of a soil, down to the depth of three feet *at least,* since the question of drainage, resistance to drought, root-penetration, etc., will depend essentially upon the nature of the substratum. In the arid region, where roots frequently penetrate to depths of ten or twelve feet or even more, it is frequently necessary to at least *probe* the land to that depth, or deeper.

The specimens should be taken in other respects precisely like that of the surface soil, *each to represent the average of not more than twelve inches.* Those of the materials lying below the third foot from the surface may sometimes be taken at some ditch or other easily accessible point, and if possible should not be broken up like the other specimens.

If there is *hardpan or heavy clay* present, an unbroken lump of it should be sent, for much depends on its character.

Seventh.—When in the case of cultivated lands it is desired to ascertain the cause of differences in the behavior or success of a crop on different portions of the same field or soil area, do not send only the soil which bears unsatisfactory growth, but also the one bearing normal, good growth, for comparison. In all such cases try to ascertain by your own observations whether or not the fault is simply in the subsoil or substrata; in which case a sample of surface soil sent for examination would be of little use. In such examinations the soil probe will be of great service, and save much digging or boring.

Eighth.—Specimens of alkali or salty soils should preferably be taken toward the end of the dry season, when the surface layers will contain the largest amount of salts. A special sample of the first six inches should in that case be taken separately by means of a post-hole auger, and then, in a different spot close by, a hole four feet deep should be bored, and *the earth from the entire four-foot column* intimately mixed before the usual quart sample is taken. Samples of the plants growing on the land should in all cases be included in the package, as they indicate very closely the agricultural character of the land.

All samples taken while the land is wet should be air-dried before sending; in the case of alkali soils this is absolutely essential.

Ninth.—All peculiarities of the soil and subsoil, their behavior under tillage and cultivation in various crops, in wet and dry seasons, their location, position, "lay," every circumstance, in fact, that can throw any light on their agricultural qualities or peculiarities, should be carefully noted, and *the notes sent by mail. Without such notes, specimens cannot ordinarily be considered as justifying the amount of labor involved in their examination.* Any fault found with the behavior of the land in cultivation or crop-bearing should be especially mentioned and described.

The conditions governing crop-production are so complex that even with the fullest information and the most careful work, cases are found in which as yet the best experts will be at fault.

Send by express, prepaid, to "Agricultural Experiment Station, Berkeley, California."

Always mark the name and postoffice address of the sender on the box or package, and on each package contained therein; also on a pencil-written label *inside* of each package. The Station staff cannot undertake to relabel such packages, and thus avoid the mistakes and losses liable to happen as the result of this omission.

It should be distinctly understood that samples sent for examination must take their place and turn on our docket, and can only in exceptional cases be advanced for immediate report. Usually such requests come in by scores in the autumn and winter, just prior to planting time, with the request for immediate report. This cannot, as a rule, be given; work already in hand must have precedence. Persons desiring such examination should not wait until so late in the season, if they wish to make use of the results for the coming planting season.