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EXAMINATION OF SOIL SAMPLES.

Several hundred letters are received annually by the Bureau of Soils asking for more or less specific information regarding samples of soils sent in for examination. A review of this correspondence shows that, while all of the States and Territories are represented, about half of the requests come from New York, Pennsylvania, Texas, Virginia, California, Illinois, Maryland, New Jersey, Washington, and Florida, in about the order named.

It appears that in about one-third of the cases submitted for an opinion the requests are for advice as to crop adaptation, about one-third for information regarding fertilizer requirements, and one-third for a definite chemical examination to determine the amount of some one or more of the mineral elements—including potash, phosphoric acid, calcium, and magnesium—of nitrates, of alkali, and of the lime requirement. About 1 per cent of the requests are for specific information requiring a special laboratory examination for the purpose of determining harmful constituents, usually suspected to be of organic nature.

In the event that the examinations show obscure conditions, and especially if they indicate the presence of deleterious substances of organic nature, and with all samples submitted for the specific purpose of determining harmful organic constituents suspected of causing abnormally low yields a long and often tedious investigation is required, based upon the methods described in part in Bureau of Soils Bulletin 74.

In very few cases is it considered necessary or advisable to make a chemical analysis by any one of the well-known acid digestion methods, as the result of such an examination appears to throw little light upon the adaptation of crops to soils; and as far as yield is concerned there are many contributing factors not shown by the analysis which affect this as much or more than the relative proportions of the mineral constituents. This matter is treated more fully in Bureau of Soils Bulletins 55 and 57 and Farmers' Bulletin 257.

When a sample is sent to the bureau for advice as to crop adaptation a determination is made, so far as can be done from a small sample, of the nature of the material, to identify the soil series to which it belongs. If the exact locality from which the sample is taken is given and information is furnished regarding the deeper subsoil, the drainage, elevation, slope, location along streams or in the uplands, the occurrence of hardpan, subsurface gravel or rock layers, or other information bearing upon the origin and mode of formation of the material, an examination of the soil and subsoil samples by the aid of the keys given in Bureau of Soils Bulletin 78 will usually determine the soil series to which it belongs. This gives at once the main characteristics of the soil and its crop adaptation under certain physical and topographical conditions which will be referred to later.

If the soil is found to belong to the Hagerstown, Sassafras, Houston, Norfolk, Knox, Marshall, Dunkirk, Clyde, or other known series, adaptations are advised on the basis of the known normal peculiarities of the series, as determined by the soil surveys. The soil sample or an aqueous extract of the same is then tested by the wire-basket method, described in Bureau of Soils Circular 18, or by the bottle-culture method described in Bureau of Soils Bulletins 36 and 70, using carbon black in the soil extract to be sure that there is no obscure substance present that will unfit the soil for normal crop development.

A sample submitted for fertilizer requirements is subjected to examination by the wire-basket method, using a normally productive soil from the same series for comparison, adding to the soil which is to be tested manure, lime, and commercial fertilizers in approximately the same amounts as used in field culture.

The requests for information regarding the mineral composition of soils are complied with through the ordinary analytical methods when it appears that the results may throw any light upon peculiarities of constitution or character of the soil that may influence its crop production. Many of these cases, it is believed, can more properly and more advantageously be considered questions of fertilizer requirement. It is often found that the more expeditious method of mineralogical examination or analysis gives fuller information regarding the mineral constitution and composition of the soil than does the chemical analysis.

All soils sent in for examination from arid regions, or generally where the rainfall is less than 20 inches per annum, are examined by the electrolytic bridge method, described in Bureau of Soils Bulletin 61, for accumulations of alkali salts, and this is carried further, if for any reason it seems desirable, by an analysis of the individual saline constituents in the water extract.

The foregoing is substantially the procedure of the bureau in examinations of soil samples submitted by correspondence.

It is necessary to bear in mind that the most thorough examination of a soil may reveal nothing of a deleterious nature or nothing indicating that success could not be had with the crops adapted to that kind of material, and yet these crops might fail if certain field indications are ignored. Success is not possible if the drainage conditions are not satisfactory, if the elevation and topography of the farm are not suitable, if the methods of cultivation and cropping are not efficient, and if the market demands and transportation facilities are inadequate. Some of these factors, which leave nothing in the sample that can possibly be revealed and others which may or may not leave effects that could only be determined by the most refined methods and after exhaustive research, are so important and so much more easily determined through a field examination that considerable space will be given their consideration.

Local limitations as to yields of crops arise partly through miscontrol and partly through misadaptation of soils to crops. The most common fault in the control of soils comes through the method and means of cultivation.

The equipment of a farm for the proper and efficient cultivation of any particular soil type should be regulated by the grade of soil. Soils ranging in grade from loams to clays require for their efficient control a farm equipment of large teams, of heavy draft animals, and correspondingly heavy tools and implements, with substantial and commodious buildings. A silt loam is usually heavier to handle than a loam, and a clay is usually heavier to handle than a silt loam, and provision should be made accordingly. On the other hand, soils ranging from sand to fine sandy loams require for their most efficient control smaller teams, lighter animals, and generally lighter tools and implements, and less commodious buildings. The heavier grades of soil not only offer more resistance in handling, but they require deeper and more thorough cultivation. Where a sand may be efficiently cultivated to a depth of 4 or 5 inches, a silt loam or clay may require 8 or 9 inches in depth of cultivation.

The kind of implements most efficiently used on the different grades of soil and particularly on some of the different soil types should be adapted to the physical character of the soil. A loose sand or sandy loam should be worked with implements that tend so far as possible to compact the subsoil, while a silt loam that tends naturally to compactness unfavorable to crops should be handled with implements that tend to keep it in the loosest possible condition.

A second condition of importance in soil control is the content and character of the organic matter. As a general rule soils respond to applications of organic matter whether in the form of stable manure or of plant remains; or, to state it in another way, soils to do their best require that a constant supply of organic matter be fed to them, and that this organic matter be of such character as to be easily digested by the soil. No standard can be fixed as to the quantity of organic matter a soil should contain, but it is essential for its most effective use that it should at all times contain readily digestible organic matter.

A soil is most efficient when crops are grown upon it in certain order of rotation. It is not to be expected that a soil will produce as large a crop of corn immediately following potatoes as it would if the corn followed sod; nor is it to be expected that the soil will produce as large a crop of wheat following wheat as it would if a crop of clover had intervened between the two wheat crops. The general principle in a rotation should be a sod followed by corn, then by a small grain, and then by sod again. This is a safe general guide where such crops are well adapted to a soil type, but the soil types differ so markedly in their adaptations and in their peculiarities that no general rotation can be expected to be successful on all types of soil; and yet, as stated above, the soil will maintain its maximum capacity only if crops are rotated in certain orders, depending upon the soil material, the soil class, and the crop adaptations.

Drainage is another factor upon which the efficiency of the soil depends. There is an optimum water content for each type and grade of soil with which the highest efficiency of the soil may be expected. If the soil is so situated as to have excessive or deficient drainage, the highest efficiency of the soil can not be expected until these conditions are alleviated.

The presence of certain weeds, and in general an abundance of weeds, lowers the efficiency of the soil for all cultivated crops, and weeds are often indicators of soil conditions which make the soil poorly adapted to certain crops.

These factors of miscontrol do not leave as a rule sufficient evidence in the soil to be determined by a laboratory examination of a sample, and where failure to maintain the soil in its highest state of efficiency results through such mismanagement, it is the part of the expert farmer or soil scientist, skilled in handling soil material in the field, rather than that of the soil chemist, confined to laboratory examination, to determine the cause of failure and the remedial measures.

Failure to maintain a high degree of efficiency of the soil for any particular crop is very often seen in the misadaptation of soil material or the use of a soil series which does not function properly for the crop grown. As an illustration, it is not to be expected that soils of the Portsmouth, Volusia, and Susquehanna series will produce under normal conditions of cultivation satisfactory crops of wheat, and with other series there are degrees of adaptation from which it is possible to eliminate many soils from consideration for commercial wheat production.

In the matter of class of material, also, the sands and up to and including the fine sandy loams are generally unsuited to wheat production, while the heavier members of the series may be admirably adapted to this crop. This illustration holds for most soils and for most crops, and it is not to be expected that equal success will be attained by the indiscriminate use of soils for any or all crops.

The structure of a soil and subsoil and often of the deep subsoil affect the adaptation to crops without imparting to the soil sample evidences of the unfavorable conditions which exist. Such conditions can only be determined by a field examination.

In many instances the depth to the subsoil determines the character, grade, or yield of crops, particularly in highly specialized industries. For example, in the production of the Sumatra leaf tobacco on the Norfolk fine sandy loam in Florida, a soil of medium depth of 6 or 8 inches gives by far the better quality, and where the subsoil is found closer to the surface or considerably deeper equally good results are not to be expected.

Topography and elevation play an important part in the adaptation of certain crops, sometimes limiting sharply the kinds and at other times the quality or the yield.

The color of the soil is often a safe guide in the adaptation of soils, indicating as it does not only material differences in constitution, but also the general nature of the processes taking place in the soil.

The presence of concretionary formations, either as gravel or as more or less continuous layers of hardpan, influence the adaptation and frequently the yield, acting in such a way as to leave no sensible effect upon the sample submitted for examination, and requiring a field investigation rather than a laboratory analysis.

All of these subjects are treated in the soil survey reports and adequate information is supplied for such areas as have been surveyed, but where misadaptation of material owing to the presence of any of these factors gives an insufficient crop, the results of laboratory investigations upon the sample, removed from its place in the field and changed in its physical conditions through packing and transportation, do not apply. It is only in the absence of these limiting conditions that such results are of value.

It, thus, is essential to the proper investigation of a sample of soil by the bureau that the purpose for which the examination is required be stated, and that information be given which will enable the bureau to identify the material, the agencies which have led to its formation, and those that have influenced the present condition of the soil. The general purposes for which such examinations may be requested may be briefly stated:

1. Adaptation of the soil for crops.
2. Fertilizer and manurial requirements.
3. Alkali determination.
4. Special chemical and mineralogical examination.
5. Investigations to reveal the presence of deleterious substances suspected to be of organic nature.

The purpose for which the soil is to be used should be stated—that is, whether for greenhouse, garden, or field crops, and the kind of crops it is intended to grow.

The general topography and elevation of the field should be stated and its relative position with respect to surrounding fields. If the soil occurs as prairie or not, this fact should be stated, together with the nature and species of the native plants, whether weeds, grass, or trees.

The occurrence of concretionary formations such as ferruginous or calcareous hardpan or nodules will often aid in the identification of material and in the consideration of the problem of adaptation and yield. If the soil is of recent alluvium, it should be stated whether of first bottom or of second bottom, and a note should be made of the drainage conditions. Any unusual phenomena or abnormal growth or death of crop should be stated, and general information as to the crops previously grown and the character and efficiency of cultivation.

It is advisable always to have a sufficiently large sample to serve for the different kinds of examinations that will be required. For this purpose there should be submitted at least 10 pounds of the top soil taken down to a change of color or of texture marking the subsoil; or if there is no particular difference between the soil and subsoil, the sample should be taken to a depth of at least 8 or 9 inches. There should also be submitted a sample of about 5 pounds of the subsoil immediately underlying; and if there is a gravel substratum below this, the fact should be stated. Care should be exercised in securing the sample to select a spot representing as accurately as possible the conditions that are to be investigated. If the examination is to be for the general characteristics of a field, it is better to make a composite sample from 8 or 10 different parts of the field. In all cases the exact location of the farm should be stated, giving distances in miles and direction from some post-office, town, or village or indicating position by land lines.

Approved:

JAMES WILSON,

Secretary of Agriculture.

WASHINGTON, D. C., *April 7, 1911.*

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