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SOIL ANALYSES
By T. C. DUNNE, B.Sc. (Agric.), Ph.D. (Calif.), Chief Plant Nutrition and Research Officer, and G. H. BURVILL, M.Ag.Sc., Commissioner of Soil Conservation

SOIL samples are often received at the Department of Agriculture together with a request that chemical analyses be done and that advice be given concerning mineral deficiencies which analysis may reveal. Unfortunately soil analyses are seldom satisfactory for determining fertiliser requirements or treatment for soils. The uses and limitations of soil analyses for mineral elements, for salinity and for pH are discussed in the following article.

PLANT NUTRIENTS
At first sight it seems reasonable to assume that, because the mineral elements needed for the growth of plants are taken from the soil, a chemical analysis of any soil should tell which ones are inadequately supplied for maximum production.

It is true that by trial with many methods, it has been possible in some places to find a means of making a soil extract which on chemical analysis shows some correlation with plant growth as judged from numerous field fertiliser experiments, but this is often restricted to one fertiliser element on one soil type and perhaps to one crop.

Unfortunately, in spite of more than a hundred years investigation, there is not yet any generally acceptable method of determining soil deficiencies of either the major or the trace elements.

By the use of suitable chemical methods, most of them time-consuming, expensive and requiring considerable skill, the total amount of the mineral elements contained in any soil can be measured. However, it was realised long ago, that the total quantities measured in this way seldom bear any useful relationship to the amounts which plants are able to get from the soils.

It is now known that large proportions of the elements in the soil are either unavailable to plant roots or are available at such slow rates that they cannot keep pace with the plant's requirements for good growth. The availability of the various elements is, then, the important factor and, as yet, there is no reliable general test of the proportions which are available.

There are many reasons why the available fractions are so difficult to measure. The availability of many elements can depend on the plant being grown. We have, for example, seen one variety of apple tree affected by copper deficiency when another variety is healthy; yet both were on the same rootstock. We know that wheat often grows satisfactorily where oats fail due to manganese deficiency. Dwallaganup subterranean clover can grow well where the Bacchus Marsh variety cannot get enough zinc. Medicago (e.g., Burr trefoil) and Melliotus (e.g., King Island melliot) species grow well on soil high in lime but subterranean clover does not. The plant itself in the final arbiter of availability.

Even with any one plant, availability can vary widely due to a number of soil factors. Though availability obviously depends to a great extent on the types of minerals of which the soil is comprised, it is known that it may be either increased or decreased by such factors as acidity or alkalinity, drought or waterlogging, the quantity of organic matter present and of course, by the previous history of applications of fertilisers, lime or sulphur.

Before any chemical analyses can be done, a soil extract has to be made. This extract is expected to measure the numerous mineral fractions from which a plant can take its nutrients. These fractions include at the one extreme, the soluble nutrients in the soil solution and, at the other extreme, the solid particles in the soil from which plants absorb by actual root contact.

The fact that so many different methods of making soil extracts have been suggested is itself evidence that no one method has yet proved generally satisfactory.

The conclusion that chemical analysis of soils cannot be used as a general and precise guide to fertiliser requirements is in line with recent opinions from California, where the climate is similar to our own and where research workers have been leading investigators of soils for many years. In a recent Californian paper*, the following statement appears:

"A number of eastern (U.S.A.) agricultural colleges analyse soil for so-called available nutrients as a service to farmers who use the analyses as a guide to fertilisation of their land.

"This service appears to be valuable under certain special conditions, but in many places with less complex problems of soil and plant interrelations than those in California, such systems have failed when tried."

Discussing attempts to determine critical levels in soils below which the use of fertiliser may pay, they state:

* "Soil Analysis" by W. R. Schoonover and J. C. Martin

Journal of agriculture Vol. 2 1953
Attempts to establish critical levels for the major nutrients, for the principal California soils and crops, have been most discouraging. Sometimes very high values indicate that all elements are in adequate supply for all crops. The usual situation is to find the values in a range for which there is, at present, no interpretation."

And they conclude—

"For the present, there is no substitute for observing plant responses to fertilisers under controlled conditions such as those found in test plots conducted by the Agricultural Experiment Station of Agricultural Extension Service."

In Western Australia, numerous field trials are conducted each year to determine mineral element deficiencies. At the same time, efforts are being made to find soil testing methods, either chemical or biological, which can be correlated with the growth responses in the field trials and which can eventually be used as an aid to determining fertiliser requirements, at least for some nutrients.

SALINITY

Soil analysis has a useful place in checking the salt status of soil. In this instance, the determination is relatively simple because the salts in which we are interested are soluble in water. A satisfactory solution is made by shaking a soil sample with five times its weight of water and on this solution the necessary tests can be made. In Western Australia common salt, sodium chloride, is usually the major component where salt concentrations occur.

Accumulation of salts in the soil can make it unsuitable for the growth of plants because they cannot absorb water from the saline solution. Where such conditions occur or develop, salts often concentrate in the soil surface in patches which remain bare and sterile. However, all bare patches are not necessarily salt patches.

From bare patches where salt is suspected, two samples are usually collected for analysis. The first is from the top one or two inches and the second from three to twelve inches deep. The results of salt determinations are considered in relation to location, topography, type of irrigation, if any, water holding capacity of the soil, and type of plant before a definite decision is made as to whether salinity is preventing, or is likely to prevent, healthy plant growth.

PH OR SOIL REACTION

pH is a guide to acidity or alkalinity in the soil and can be accurately determined in the laboratory. The method used is to shake a suitable amount of air-dry soil with five times its weight of water and to measure the pH of the suspension with suitable electrodes and equipment.

The pH scale is 0 to 14 with pH 7 the mid point or neutral point. Soil pH values are usually in the range 4 to 10; pH 4 to pH 7 are acid; pH 7 to pH 10 are alkaline.

Most crops and pasture plants do best within the range of pH from 5.5 to 7.5. Outside this range the availability of some essential elements may be seriously affected or associated microorganisms, such as the nodule bacteria, may not thrive. Nevertheless some species do grow at pH values as low as 5, and others at a pH value as high as 9.

Unless it is exceptionally high or low, the pH of a soil cannot be considered solely as a cause of poor growth but, with other evidence, can sometimes help an experienced officer in deciding on the cause of unsatisfactory growth of crops or pasture.

GENERAL

It will be appreciated from the above brief resumé that farmers should not forward soil samples for chemical analyses if it is information about fertiliser requirements that is wanted. The best procedure for any farmer is to get in touch with the district agricultural officer so that the problem can be discussed with a person who is familiar with the district and its soil peculiarities. The officer is often helped by the fact that certain mineral deficiencies cause recognisable characteristic symptoms on plants and that some deficiencies are associated with definite soil types.

The district officer should also be approached when it is suspected that excess salinity is the cause of poor growth. Soil samples will be taken if he considers this action would be helpful.

When an agricultural adviser is not available, the problem should be stated in a letter to the Department of Agriculture, Perth, but soil samples should not be forwarded until specifically requested.

It should be noted that, although it is recommended that farmers do not take soil samples themselves and forward them direct, provision was made some years ago for various analyses of waters, soils and agricultural produce to be carried out by the Government Chemical Laboratories at a reduced fee for farmers.

The present general fees are:

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<th>Salt or salinity</th>
<th>15s. per soil sample</th>
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<tbody>
<tr>
<td>pH</td>
<td>15s. per soil sample</td>
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but these rates are reduced to one third for bona fide primary producers.
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