PEDOLOGICAL PATTERNS OF SOIL FERTILITY

By E. R. ORCHARD

Fertilizer advisory services based on soil analysis have proved useful for raising the efficiency of agricultural production in many countries. The technique has the advantage of low cost as well as speed so that corrective measures may be taken even during active growth of the crop. With a few notable exceptions, where intensive field and laboratory studies have been conducted, this approach has thus far not proved very successful in South Africa. This is probably because the empirical methods and arbitrary criteria commonly used in estimating the pool of available N, P and K in soils are not sufficiently specific when applied indiscriminately over such a wide range of soils as occurs in this country. Even in the Netherlands, where soils are relatively uniform or closely related, allowance is made for different soil types when soil analytical data are interpreted for advisory purposes.

Until the technique can be improved and refined by more intensive investigation and calibration locally against actual responses in the field, the soil classification system could meanwhile serve as a useful guide to fertility patterns associated with our different soil groups and series.

In the Tugela Basin, where the soils have recently been mapped and classified at the series level, it is possible to recognize distinct fertility patterns characteristically associated with individual series. This correlation has already proved very useful not only for purposes of farm planning but also in rendering advice to farmers on fertilizer and cropping programmes. Thus crops on certain series respond consistently to potash, on others only to phosphate and still others to particular combinations of lime and the major nutrients. Moreover, field experiments with different fertilizer combinations and levels have served to reveal the yielding potential of different crops on the various soil series. Evidence is accumulating to show that productive potential as well as patterns of response to fertilizers remain reasonably constant within any one series regardless of where it may occur. The task of advising farmers is therefore greatly simplified once soils can be classified correctly and where definite response patterns have been established by field experimentation. It follows also that maximum advantage may be gained from field experiments only if experimental sites are selected with careful reference to the soil map.

Currently accepted systems of soil classification are all based on chemical, physical and morphological characters of the soil. Criteria for differentiation comprise such properties as pH, the nature and amount of exchangeable cations and clay minerals, mechanical composition, organic matter content as well as morphological features of the profile. Taken together, these reflect the past history of the soil, i.e., the conditions under which it was formed. The soil forming factors thus determine the fate of mineral nutrients present in the original parent material.

Intensely weathered and leached sub-tropical soils of high rainfall areas in Natal are characteristically acid and of low natural fertility in contrast with the less leached soils of hotter or drier areas. The latter usually contain larger reserves of available potash, phosphate and trace elements but may be low in nitrogen. Because of the relative importance of climate, i.e. rainfall, temperature and evaporation as a soil forming factor, the various series do not occur haphazardly but according to definite soil ecological zones which correspond broadly also with the regional climate and vegetation. In this way the same parent rock or material may give rise either to naturally fertile or infertile soils, depending on how climatic factors have influenced the intensity of weathering and degree of leaching to which the soil has been subjected.

The nature and amount of the clay minerals, the distribution of positive and negative charges, pH, the degree of saturation, the state of the iron and aluminium compounds are important criteria in classifying soils. These same properties largely determine also the level of fertility and thus provide the link between pedological character and the natural fertility status of soils. Further supporting evidence of this interdependence may be derived from a consideration of the chemical composition of the equilibrium soil solution. This solution, which largely reflects the nutrient supplying powers of the soil, is also thought to have a characteristic composition for each series.

The pedological nature of the soil can be successfully used as a general guide to fertilizer requirements only if the soils have been classified correctly and where sufficient evidence from numerous field experiments is available. Ordinary farming activities are unlikely to change the pedological character of the soil but members of any one soil series may vary in fertility, depending on cropping systems and past fertilizer practices. Provided they have previously been calibrated, even empirical soil analytical methods may be used with success in such cases to distinguish between deficiency and sufficiency within a series.

No claim for originality is made for the general views advanced here. The object is merely to draw attention to some practical advantages which flow from careful pedological work. Any field agronomist who has learned to recognize and distinguish between the various soils in his area and who is familiar with the characteristic response patterns of crops on the more important series he deals with, will be at a considerable advantage, even if advice is required in areas where soil maps are not yet available. Experience in the Sugar Belt and elsewhere has also shown that one of the main benefits to be derived from detailed soil maps, based on a sound classification system, is that it provides the only acceptable basis on which to plan a field research programme aimed at improved advisory services to farmers.

Summary

Soil analytical data obtained by empirical methods can be used successfully for fertilizer advisory purposes only if adjusted for variations in the pedological nature of the soil. Many of the soil series identified in the Tugela Basin show characteristic fertility patterns. Once these response patterns to various nutrients have been established by field experimentation, the soil map may serve as a useful aid in fertilizer advisory work until such time as analytical criteria for sufficiency have been worked out for the more important regional soil series.

Mr. Lintner: Professor Orchard in his hypercritical approach to his work almost achieves the status of a perfectionist. He has set out clearly in his paper the ideas we should follow at all times.

Mr. du Toit (in the chair): Professor Orchard refers to a series of fifty or sixty experiments and says they must be calibrated on a soil series basis. But surely it is the response that must be calibrated to the analysis of the soils, as has been done in the sugar belt. The Experiment Station has admittedly done pioneering work in soil series classification. But, nevertheless, if it is found, for example, that using an empirical method (and I am giving empirical its true meaning), there is an excellent correlation between soil analysis and potash response, and that above a certain level of soil potash there is no response, while below that there is a response, then, even though such observations are empirical, they are extremely useful and largely cut across soil series.

The minerology of the series on the other hand will certainly affect the fertilizer advice. We believe here at the Experiment Station that soil advice based on an empirical method is sound, but the soil series is also as far as possible taken into account. We would like a case history to be built up for every field, this case history to combine the soil series, the climatic conditions, history of past yields and chemical analysis, etc. and then only shall we be able to give the best form of advice.

Professor Orchard: Mr. du Toit seems to be in favour of both soil series and present empirical methods. But when we come to finer calibrations, which is the stage the sugar industry has reached with its high degree of efficiency, then present methods can be improved upon.

If you have two soils, one with 0.2 m.e. potash and the other with 0.4 m.e., the higher one may respond to potash and the lower one will not, which is contrary to expectation.

This is what we find, but you do not find it in the cane belt because you deal with an isolated group of soils that have a high degree of uniformity. Because of your special conditions you should not draw conclusions as to what may be applicable everywhere.

Mr. du Toit: Dr. Cleasby referred to the director of Rothamsted's statement that no matter how good you research is, unless it finds practical application it is no good at all.

Dr. Macvicar: It is important to bear in mind that pedological series are not agricultural units. They are the units the numbers of which have the most properties in common. Agriculture is but one field using a knowledge of soils. In soils under cane, possibly under irrigation, you would handle differently, for example, your Shortland series and your Fernwood series.

Mr. Whitehead: The views expressed at the meeting today indicate a degree of unanimity which is rather surprising. I would like to introduce a note of heresy, particularly in relation to soil series classification. First we should, I think, bear in mind that basic requirements for plant growth do not include soil. Plants can in fact be grown quite well without it. Dr. Macvicar suggested that on mapping soils we need to associate soil series with agriculture; in fact to extrapolate the results of studies within a particular series. Such extrapolation can be and has in fact been harmful and it has been my experience in the Far East that it is not feasible. In a massive series of simple field trials designed in conjunction with F.A.O. and put down over a range of soil series, it was found that responses were so variable that no overall benefit from the application of fertilizer was discernible. Studies of the variations in response failed to show correlation with soil series. Indeed it was found that the differences due to soils, classified mainly on a basis of their morphology, were relatively unimportant.

This opinion has been expressed recently by B. E. Butler, Officer in charge of the Division of Soils Laboratories in Canberra. He states: "The correlation between soil types and agricultural production is uncertain or absent and (can) not be enjoined as a general principle nor used realistically as the basis for agricultural technology". He claims that there is a great need to clarify soil properties and correlate these with yield and he distinguishes between these properties and morphological identification of soils. It should be of interest to hear the reaction to this argument.

Professor Orchard: Replying to a question from the floor, said: Soil analysis will always be necessary, despite the fact that one can to some extent correlate soil series and the results of field experiments.

Mr. Allsopp: Mr. Murdoch did a survey for Ubombo Ranches in Swaziland and it proved of tremendous value to us in laying out our fields under irrigation. Yield potentials he gave for the various series proved to be very close to the actual figures.

Mr. G. D. Thompson: It appears to me that pedologists believe that wherever the soil series exists the climate will be the same. I think the climate will vary a great deal over a given series and you will always have to take the climate into account. This is particularly important when interpreting experiments.

Dr. Loxton: I know the area referred to by Butler of Australia. The system of classification was derived entirely from morphological features. In attempting to derive a more accurate classification great detail was gone into.

We take the constitution of the soil into consideration and not merely its morphological features, also its physical and chemical properties, so that we classify the whole soil and not part of it.

Furthermore, when dealing with the matter of irrigation, for instance, on the particular soils referred to by Butler, they all had one striking characteristic, namely a very slow permeability which tended to cut across the apparent morphological features.

When carrying out a survey for irrigation purposes we take into consideration our basic concept of soil series. But when we make an assessment of the capabilities of different soils for irrigation, we tend to establish very often what we call single factor maps. This might be a major limiting factor influencing irrigation — it may be a physical condition of the soil. It is therefore not surprising that when he applied a particular use to a soil he cut across series differences.

This afternoon discussion has centred around the importance of the soil series. The more work being done on soils to discover and determine their properties the more essential it is for us to determine more accurately, more specifically and more exclusively each particular series. The classification in the sugar belt is not specific enough in my opinion. Too much deviation from the norm is permitted in the definition of this series. I realise Dr. Beater has probably done this because he may have felt that too large a number of series would create difficulties.

Mr. du Toit: Dr. Beater has not been directed by the Experiment Station to limit the number of series. I believe a number of Dr. Beater's series were actually eliminated during the process of registration by Dr. Loxton, because he did not think they differed sufficiently!