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USE OF APPROPRIATE FERTILISER FOR RUBBER BASED ON SOIL AND LEAF NUTRIENT SURVEY

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SUMMARY

The methods, based on soil classification and on soil and leaf analyses used in the Rubber Research Institute of Malaya to assess the specific fertiliser requirements of individual fields are discussed. The prospect of their use for rubber in Ceylon is also considered.

INTRODUCTION

The use of fertiliser in the cultivation of rubber in West Malaysia is an established practice. There is no doubt that on the leached impoverished tropical soils supplementing the nutrients available from soil by application of artificial fertilisers is beneficial. This does not however mean that the practice of using any type and amount of fertiliser is necessarily beneficial. Optimum growth and yield of plants can be expected only by properly balancing the nutrients to the need of the trees. In view of the known differences between soils, it is important to alter, and alter appropriately, the type and amount of the nutrients applied, so that a balanced nutrition of the trees is maintained. Optimum growth and yield can be expected only by such balanced nutrition and not by the indiscriminate application of fertilisers. In fact, indiscriminate application has often been found to depress the yield or growth instead of improving it (Anon, 1967 ; Pushparajah, 1969).

Until the early 1960s, the fertiliser recommendations offered by the Rubber Research Institute of Malaya were general in nature. These general recommendations were formulated by averaging the nutrients that showed response in different areas at different times. That such general fertiliser recommendations cannot provide the best growth is clearly shown by the variability of the responses that are observed in field manuring trials ; this points towards the need of a more discriminatory use of fertilisers on the basis of the requirements of individual soil or field conditions.

Assessment of the physical conditions of the soil by soil classification and survey and the development of leaf and of soil analysis as diagnostic techniques have now made it possible to assess the discriminatory fertiliser requirements for individual soil types or areas. Since 1962, the Rubber Research Institute of Malaya has developed a method of assessing the specific fertiliser requirement of an area of soil on this basis and has offered recommendations to plantations. To date, over one million acres of land under rubber cultivation have received such manuring recommendations and, to the best knowledge of the authors, these recommendations have been found to be an improvement over the previous general fertiliser formulations in West Malaysia. The purpose of this paper is to discuss the basic knowledge required for such assessment of specific fertiliser requirement for rubber, and to examine to what extent such information is already available in Ceylon either fully or partially. It should then be possible to assess the benefit that is likely to be derived by adopting this discriminatory method for fertiliser recommendation for rubber in Ceylon.

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ASSESSMENT OF SPECIFIC FERTILISER REQUIREMENT

Successful assessment of specific fertiliser requirement for any one site or homogenous soil unit depends on four aspects of soil/crop investigations, namely :

(a) development of a proper soil classification system on the basis of physical and morphological characteristics of the soil and availability of soil maps,

(b) results of fertiliser trials,

(c) soil nutrient status,

and (d) leaf nutrient status.

These four aspects are discussed in turn.

Development of a proper soil classification system and availability of soil maps

Physical and morphological characteristics of the soil have an overriding influence on its degree of suitability as a medium for growth of plants. Only when a suitable physical medium is provided, can nutrition be adjusted so as to give the optimum growth or yield. Moreover, the physical condition of a soil itself has direct effect on the availability of the nutrients that may be present in or applied to the soil. It is therefore necessary to classify the soils into homogenous units with regard to their physical properties before their nutrient-supplying power and therefore their fertiliser requirement can be considered. To this end, soils are classified according to the physical and morphological properties of the different horizons of a soil profile. Classification units considered homogenous with regard to the agricultural purpose in mind are decided upon; these units are then mapped by physically examining the soil properties on the ground. Such soil classification, survey and mapping are a basic requirement for establishing proper manuring and other agricultural practices (Avery, 1962).

In Malaysia, a classification system on the above basis was initiated by Owen (1951) and has since developed and proved to be beneficial for the purpose of assessing the fertiliser requirement of an area (Pushparajah & Guha, 1968 ; Guha, 1969). Over one million acres, about 1/4 of the total area under rubber, have so far been surveyed at series level, while detailed soil maps in the scale of 12,500 : 1 or 5 in. to a mile are under preparation. The detailed classification of soils in Malaysia for such mapping are based on soil properties which are considered relevant for growth of rubber trees (Guha, 1968). Properties such as parent material, the sequences of soil horizons in the profile, the texture, structure, consistency and colour of the soil in the different horizons are taken into consideration for classification at series level. The other agronomically important soil properties, such as the texture of surface soil, the depth of the soil, the slope of the land, and the presence of concretions and/or stones are considered for sub-classification of the soil series into phase level. The mapping units at phase level therefore provide most, if not all, the morphological and physical characteristics of soil that are agronomically important for cultivation of rubber.

A detailed soil classification therefore allows separation of soils into homogenous units with similar physical and morphological characteristics. The soil maps, besides showing the areas of uniform soil characteristics, also provide a knowledge on the variability between soils and the extent of each soil type. This allows better selection and siting of field experiments and hence more specific fertiliser recommendations.

In Ceylon, soil surveys appear to have been carried out in the scale of 63,000 : 1 or 1 in. to a mile for the rubber growing areas, the mapping units being at series or association level. For agronomic requirements, including manuring requirements, sub-classification of series at phase level and mapping of the soils at phase level are desirable if this is not available.

A comparison of the established soil series for areas under rubber in Ceylon and those in West Malaysia (Silva, 1969) should prove beneficial in adopting the findings and experience in one country for application in the other.

Results of fertiliser trials

Long-term fertiliser trials have been carried out in Malaysia since the early 1930s. Even currently fertiliser trials are being conducted in many different forms and designs. An overall assessment of the results so far obtained (Haines & Falconer Flint, 1931 ; Owen *et al.*, 1957 ; Bolton, 1964 ; Anon, 1967 ; Pushparajah & Guha, 1968) no doubt leads to a conclusion that application of fertiliser is beneficial. But lack of reproducibility of responses on different areas equally makes one feel uncertain of the advantage on each and every individual field from application of any general fertiliser formulation. This difficulty of interpreting the results of manuring trials for wider application outside the experimental sites led to the search for agronomic parameters which reflect the responses of crops to fertiliser application (Guha & Pushparajah, 1966 ; Pushparajah & Guha, 1968). Isolation of soil into homogenous units allows for an improvement in reproducibility of results, but differences in chemical properties within the same soil type, can also give widely different results.

These differences in the responses of rubber to fertiliser application between different soil types and between different sites of the same soil type have also been observed by the agronomists and soil scientists in Ceylon (Silva, 1970). Hence, a correlation of the results of fertiliser experiments with some diagnostic tests such as soil or leaf analysis is essential for wider application of results of manurial trials. Proper siting of experiments is also necessary to cover a sufficiently wide range of the results of the diagnostic tests. Detailed soil and leaf nutrient surveys assist in such selection.

Soil nutrient status for diagnosing fertiliser requirement

Use of chemical soil analysis to determine the available nutrients in soil for diagnosing fertiliser requirement for rubber was carried out by Owen (1953). The methods used were empirical and classical and involved extraction of the soil nutrients by chemical reagents. " Critical " soil nutrient values have been deduced for some soil series on the basis of past experimental results, although these are limited making such values approximates, to differentiate between soils which are likely or not likely to show responses in growth and/or yield to manuring (Guha, 1969). These values are shown in Table 1.

TABLE 1

"CRITICAL" SOIL NUTRIENT CONTENTS FOR *HEVEA* ON DIFFERENT SOIL SERIES

Nutrient	Soil series			
	Selangor	Rengam	Serdang/Munchong	Kuantan
N, %	0·21 (+)	0·10 (+)	0·14 (+)	0·16 (+)
P, ppm	339 (—)	101 (+)	254 (+)	2306 (—)
K, me/100 g	3·4 (—)	0·2 (+)	1·1 (+)	0·4 (+)
Mg, me/100 g	10·3 (—)	n.a.	2·4 (+)	6·4 (—)

n.a. = not analysed.

(+) Levels below which response is likely, being values for control plots of experiments where application of the respective nutrients showed response in growth and/or yield.

(—) Levels above which response is not likely, being values for control plots where application of the respective nutrients showed no response in growth and/or yield.

While the use of such chemical soil analysis has improved the assessment of fertiliser requirements over the previous general fertiliser application, establishment of such critical values for all the different soil series have not so far been possible because of insufficient experimental data and because the chemical methods used being empirical, could not be extrapolated to other soils where manurial trials were not available. Further, the sensitivity of the current methods of soil analysis is also limited.

In order to improve the diagnostic technique of soil analysis, more theoretically sound soil assessment methods than the currently used empirical methods are at present under investigation (Singh & Talibudeen, 1969 ; Singh, 1970). It is known that the availability of soil nutrients to plants does not really depend on the total amount of the nutrients in the soil but on the nature of their existence and binding in the soil. This nature of existence and binding is governed by physico-chemical reactions. Consequently, a soil test method which takes into account such physico-chemical reactions should prove to be more meaningful than the above empirical methods. Such tests are now under development at the Rubber Research Institute of Malaya, the results of the tests being currently calibrated against responses observed in fertiliser experiments.

Assessment of available nutrients from soil for rubber in Ceylon is a subject that requires further development. Potassium status of some rubber growing soils in Ceylon has been reported by John (1967). A survey of the nutrient status with respect to all the major nutrients of soils on which rubber is grown is required to establish the ranges of the nutrients in the different soils. This will allow an assessment of the suitability of existing fertiliser experiments. It will also indicate whether or not a single fertiliser recommendation would be suitable for a soil series or group of soil series, which may be possible if there is a reasonable amount of homogeneity in nutrient contents.

Leaf nutrient status for diagnosing fertiliser requirement

The technique of using leaf nutrient contents to assess the nutrient requirement of rubber trees was developed by Shorrocks (1961, 1962, 1965), Chapman (1941), Beaufils (1955, 1958, 1959) and Guha & Narayanan (1969). With the recent developments in instrumentation, chemical analysis of plant materials can now be made comparatively simple and rapid, but the proper interpretation of leaf analysis data for fertiliser requirements is still limited by the effect of several factors, on leaf nutrient contents. These factors include the position of the leaf in the canopy, the age of the leaf, effects of climate and weather, clonal differences and interactions between nutrients. A proper interpretation of leaf analysis requires (*a*) rigid standardisation of the sampling methods to reduce the variability caused by these factors, and (*b*) calibration of the leaf nutrient contents with yield and growth in fertiliser trials. A sampling procedure to remove the positional and tree to tree variation was recommended by Shorrocks (1964), while a correction factor for the leaf age variation was recommended by Guha & Narayanan (1969). The effects of climate and weather which lead to seasonal variations in leaf nutrient contents, and the interactions between nutrients however are still serious limitations which restrict the usefulness of leaf analysis and need further development. Nevertheless, the method of leaf analysis has contributed to better qualitative and semi-quantitative assessment of fertiliser needs when used in conjunction with soil analysis. The levels of leaf nutrient contents which very roughly indicate their sufficiency and deficiency have been given by Anon (1963) and are reproduced in Table 2.

TABLE 2

"CRITICAL" LEAF NUTRIENT CONTENTS FOR *HEVEA**
(Expressed as % of oven-dry sample)

Nutrient	Nutrient level below which response likely		Nutrient level above which no response likely	
	Leaves exposed to sunlight	Leaves in shade of canopy	Leaves exposed to sunlight	Leaves in shade of canopy
Nitrogen	3·20	3·30	3·60	3·70
Phosphorus	0·19	0·21	0·25	0·27
Potassium	1·00	1·30	1·40	1·50
Magnesium	0·23	0·25	—	0·28

* As in Annual Report of the Rubber Research Institute of Malaya, 1962.

Comparatively more work has been done in developing leaf analysis than soil analysis as a diagnostic tool for the assessment of the fertiliser requirements for rubber in Ceylon (Silva, 1970). The results indicate that the leaf samples should be collected during the period May to October, as otherwise the marked wintering and refoliation conditions may over-shadow the nutrient levels in leaves and thus make proper interpretation of leaf analysis results difficult. Samples from three different positions of the crown that were examined do not show any significant difference ; and as such, any of these positions could be taken at present for standard sampling purposes. The positions selected should therefore be on the basis of practical convenience. Although critical levels do not appear to have been firmly established, it appears that values such as are used in West Malaysia may be taken initially for use in Ceylon conditions until such time as the critical values have been worked out or confirmed under Ceylon conditions.

CONCLUSIONS

The discriminatory use of fertilisers in West Malaysia is based on leaf and soil analysis as diagnostic tools. The precision of these methods is improved by proper classification of soil into homogenous units with similar physical and morphological characteristics. The critical values of leaf and of soil analysis which indicate likelihood of response or otherwise to fertiliser were determined from manurial trials. On its own, neither manurial trials, nor leaf or soil analysis are adequate, each being limited in its current stage of development.

The adaptation of these techniques should prove beneficial under Ceylon conditions. Available information in Ceylon on soil or leaf studies together with adaptation of the results obtained in West Malaysia, should permit use of the above techniques in practice for detailed recommendations for individual fields or homogenous soil units.

Recording of soil, leaf and yield data of individual fields during survey, in a manner that can be summarised and examined easily, would build up information on the variety of soil and leaf nutrient conditions that exist in Ceylon. Such information will in turn indicate the adequacies or otherwise of the methods currently used and also, when examined carefully, would indicate the direction of research which is likely to be most useful in the future.

While the above method for giving discriminatory fertiliser advice is being recommended for improving the nutrition of yield of trees, on the one hand, and for building up sufficient data on the different soil types and on soil and leaf nutrient contents, on the other, the need for simultaneous research to determine the suitability under Ceylon conditions of the standards used in West Malaysia, and improvement in sampling and analytical techniques, cannot be over-emphasised.

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QUESTIONS AND ANSWERS

Question : If you have to select *only one* out of the four methods mentioned for recommending fertilizers, which will you select ? (Anon).

The four methods — (1) Soil classification

(2) Fertilizer trials

(3) Soil analysis

(4) Foliar analysis

Answer : This is a rather difficult question to answer. I could only make the observation that recommendations based on fertilizer experiments are the most reliable but are also time-consuming. Soil classifications (survey), soil analysis and foliar analysis should all be combined in recommending fertilizers based on the technique of soil and foliar survey. Any single method will not be sufficient.

Question : Is there any danger on giving fertilizer recommendations based solely on leaf analysis ? (Anon).

Answer : In Malaysia it has been observed that the most dependable results are had when recommendations are based on soil and leaf analysis.