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# The Fertility Characteristics of the Rice-growing Soils of Ceylon

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## INTRODUCTION

It is generally observed that a controlled supply of water is by far, one of the most important factors which set a limit on the per acre yield of rice. The regional rice yield statistics in Ceylon clearly reflect the conditions of water supply which obtain in the respective rice-growing regions of the country; likewise, the per acre yield figures over a period of the last twelve years indicate a significantly steeper upward trend in regions which benefit from a regulated water supply. Nevertheless, despite limitations imposed by a capricious water supply, it is strikingly manifest both in Ceylon as well as in other rice-growing countries that the optimum use of chemical fertilizer could contribute more than any other single practice in stepping up the present rice yields. In the context of this country which yet continues to import the totality of its chemical fertilizer requirements, the importance of reaping the maximum benefits from the applied chemical fertilizer need hardly be emphasised.

The results of almost three decades of field experiments which have been conducted by the Department of Agriculture in its research stations and farms, and also recently in cultivators' fields, have enabled an identification of the more important fertility characteristics of our rice-growing soils in as far as these influence rice yield and fertilizer practice. Recent research in this country has also made a significant contribution towards a clearer elucidation of plant-fertilizer relationships in respect of rice. In the light of our contemporary knowledge and experience, it is therefore evident that an all-island survey of the fertility characteristics of the rice-growing soils could provide a versatile basis for formulating a rational programme of island-wide fertilizer use for this crop.

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The chief objective of this project which commenced in March 1962, was to identify and map on an island-wide scale the regional distribution patterns of those measurable soil characteristics which profoundly influence both rice yield and fertilizer use in this country.

A review of past studies on the rice-growing soils of Ceylon reveals several isolated but useful investigations. Bruce (1922), compared the analytical data for some typical rice soils of Ceylon with those of Burma, South India and Thailand. Joachim and Kandiah (1938), have reported the results of analysis of nine paddy profiles as well as the partial examination of twenty-seven other paddy soils. The potash status of thirteen rice soils was studied by Ponnampereuma (1952), who had also subsequently estimated the nutrient status of soils sampled from scattered experimental plots (1960).

### **GENERAL PRINCIPLES WHICH UNDERLIE THIS STUDY**

It is our view that the usual soil profile characteristics which determine the performance of upland arable crops cannot legitimately be assigned a comparable measure of agronomic significance under the prevailing conditions of flooded rice culture in the humid and semi-humid tropics. It is therefore pertinent to question the basic premises of a programme which seeks to map rice soils in terms of conventional soil types, series, families and groups. On the other hand, a more rewarding approach would be to take a closer look at the available experimental data in this country which demonstrate the empirical relationships that exist between certain individual soil characteristics and the responses of the rice crop. Undoubtedly, in the technological background of a developing country, it would be more expedient, as a first step, to exploit such already available advanced scientific information prior to embarking on projects with more sophisticated objectives.

Soil fertility is essentially a soil quality which is collectively determined by those component soil characteristics which govern the fertility status of the soil. Nearly all these individual soil characteristics which are known to govern the fertility of a soil are readily measurable. The term 'fertility characteristic' as used in this publication mainly refers to such measurable individual soil characteristics which are presently known to govern rice yield and fertilizer use in this country.

## FERTILITY CHARACTERISTICS OF THE RICE-GROWING SOILS OF CEYLON

On the basis of our present knowledge and local experience, the more important soil characteristics which govern rice yield and fertilizer use are :—

- (a) Soil texture and soil drainage
- (b) Soil pH
- (c) Organic Matter and Nitrogen status of the soil
- (d) Phosphorus and Potassium status of the soil
- (e) Cation Exchange Capacity of the soil

Other soil characteristics which assume a measure of importance in the nutritional relationships of rice are :—

- (a) Nature and distribution of individual cations
- (b) Free Iron content
- (c) Available Silica

Two soil characteristics which are commonly recognized to be of considerable significance by most rice farmers of the Orient are soil texture and soil drainage. It is observed that the descriptive terms which have been devised by local farmers to characterise soil texture and soil drainage correspond to fairly broad textural and drainage class groups which are themselves distinctive enough to be employed as a basis for differential cultural recommendations. It is in respect of the other soil characteristics however that the local farmer shows almost a complete lack of appreciation. This is by no means surprising, because this branch of knowledge is essentially a product of recent twentieth century soil science. Furthermore, these soil characteristics have to be measured with special scientific equipment, and this is normally beyond the scope of their traditional skills. In order to fill this gap in their knowledge, it is proposed that instructive maps which depict the local distribution patterns of these measured soil characteristics be prepared; and these then be effectively translated to the field by the comparatively better educated and technically trained extension staff.

## PHYSICAL SETTING OF RICE FIELDS IN CEYLON

The physical distribution of the rice fields in Ceylon are shown in Map 1, which also shows the division of the country into its main agroclimatic zones as well as the present administrative districts. The dry zone receives an annual rainfall of less than 50 to 75 inches, all

of which is received in four to six months during a sequence of two cropping seasons. Annual rainfall in the intermediate zone is around 75 to 100 inches and it is more or less evenly distributed throughout the year. The wet zone receives an annual rainfall of over 100 inches, while in the ultra-wet zone it is often in excess of 175 inches. The present administrative districts which correspond to the numbers as shown in Map 1 are as follows :—

- |                  |                   |
|------------------|-------------------|
| (1) Jaffna       | (12) Amparai      |
| (2) Vavuniya     | (13) Kegalle      |
| (3) Mannar       | (14) Kandy        |
| (4) Trincomalee  | (15) Nuwara Eliya |
| (5) Anuradhapura | (16) Colombo      |
| (6) Puttalam     | (17) Ratnapura    |
| (7) Polonnaruwa  | (18) Moneragala   |
| (8) Batticaloa   | (19) Kalutara     |
| (9) Matale       | (20) Galle        |
| (10) Kurunegala  | (21) Hambantota   |
| (11) Badulla     | (22) Matara       |

The term low country as used in this text, refers to that region of the country which is below 500 ft. elevation. The region which lies between 500 ft. and 3,000 ft. elevation is referred to as the mid country, while the region which is above 3,000 ft. elevation is referred to as the up country.

Most of the rice fields in Ceylon are found on recent alluvial deposits. In the relatively mature landscape of the low country regions, the alluvial deposits occur along broad flat valleys which are separated from each other by the undulating residual land. Most of this residual land is either under permanent plantation crops in the wet zone, or is subject to 'chena' or shifting cultivation in the dry zone. Complete control against soil erosion is not possible on this residual land during flash storms. As a result, deposition of soil material in the valleys is a significant phenomenon even at present. Soil drainage is observed to closely follow the topographical features of the valley, and is in turn fairly well reflected in the soil profile features. A typical topo-sequence has been described in the Hewagam Korale of Colombo district by Thenabadu, Gunasekara and Fernando (1958).

The alluvial deposits which occur in the flood plains of the major rivers and streams constitute some of the best rice fields in Ceylon, especially in the dry zone. Most of the new major colonization

schemes of the dry zone are located on such lands. With the additional advantage of a controlled water supply, the yield potential of these fields is indeed quite considerable.

Adverse drainage conditions are perhaps the most dominant features of the rice fields of the south-western low country. The chief contributory factors being a poor landscape drainage as well as an impervious clay substratum which occurs at varying depths. Thenabadu (1960), has described the profile features of a rice soil where the poor drainage conditions could be attributed to such an impervious clay substratum. Soil ameliorative measures are found to be of little consequence unless the gross limiting factors of poor drainage and excessive flooding can be remedied. Vermaat (1956), describes the conditions which exist in these problem areas, and he has also defined the specific field problems which need remedying.

In the more youthful landscape of the mid country and up country regions, the alluvial deposits are usually confined to narrow valleys which are separated by residual lands of sharp relief. The rice fields which are located in such valleys have satisfactory drainage conditions. Rice fields which are found on the terraced slopes of the mid country and up country regions have very good, if not excessive drainage conditions.

In mineralogical composition, the rice soils would generally resemble the parent soil materials from which they have been derived. It is therefore probable that the rice soils would broadly reflect most of the mineralogical characteristics of the great soil groups of Ceylon as identified by Moormann and Panabokke (1961), with the possible exception of those mineralogical characteristics which result from the distinctive pedogenic processes which are operative under flooded conditions.

### **SURVEY AND SAMPLING PROCEDURE**

This survey of the fertility characteristics of rice soils was carried out according to the following procedure :—

The distribution patterns of the rice fields in each one inch to the mile topographical sheet of the Survey Department were initially examined ; and the field investigations on each such sheet were planned on the basis of this distribution pattern. The minor landscape features of the rice fields were stereoscopically analysed with the aid of air photographs of 1 in 40,000 scale combined with sufficient field checks. Thereby, the specific land-form units which characterise

the rice fields of a particular natural region were identified. Soil sampling was done at a modal site in each land-form unit of the 'yaya'. The selection of rice tracts or yayas was on a random basis, while the distribution of the sampling sites was as far as possible adjusted to the distribution pattern of the rice tracts in each topographical sheet. A total of 2,715 sampling sites covered the 1.25 million acres of rice fields in the country.

Soil sampling was done to a depth of nine inches with a spade. Three soil samples were taken from around each modal sampling site and composited into a single sample which was collected at field moisture condition into a strong polythene bag. The site features and the field characteristics of the soil were also described. On the average, one field unit was able to complete ten sampling sites per working day.

### LABORATORY STUDIES

The soil samples which were received at the laboratory in labelled polythene bags were air dried, crushed with a wooden roller, and all soil particles failing to pass through a 2 mm. sieve were expressed as stone and gravel. Prior to air drying, a sample of soil was taken from the polythene bag for determining the pH at field sampling moisture content. The less than 2 mm. air dry fraction from each soil sample was used for laboratory analysis. A total of 2,715 soils were analysed for pH, conductivity, available phosphorus and exchangeable potassium; and on selected samples out of this total, 1,139 samples were analysed for organic matter; 497 samples for nitrogen; and 281 samples for cation exchange capacity, total exchangeable bases, individual cations, available silica and free iron respectively. Soil colour and texture were also determined on all the air dry laboratory samples.

Methods of analysis employed were mainly those outlined in Metson's 'Methods of Chemical Analysis for Soil Survey Samples' (1956). For saline and alkaline soils, methods set out in U. S. D. A. Handbook 60, (1954), were followed. The method employed in respect of each soil characteristic is briefly outlined below.

#### pH

The pH was determined by the glass electrode in conjunction with a saturated calomel electrode using a Beckman 'Zeromatic' model pH meter. Determinations were made on a 1 : 1 soil—water mixture as well as on a 1 : 1 soil—1 N KCl mixture.

### **Conductivity**

Conductivity was measured in a 1 : 5 soil suspension in distilled water at a temperature of 25°C.

### **Organic Matter**

Organic carbon was determined by the Walkley and Black rapid titration method, and the value of 'organic matter' obtained by multiplying the organic carbon value by 1.72.

### **Nitrogen**

Total nitrogen was determined by the semi-micro Kjeldahl method.

### **Exchangeable Potassium**

Following the method outlined in C. S. I. R. O. Technical Memorandum (1954), the soil was leached with 1 N ammonium chloride solution and the potassium in the leachate was determined by a 'Lange' model flame photometer.

### **Available Phosphorus**

Was determined by Olsen's method on a 1 : 20 soil—0.5 M sodium bicarbonate extraction. Phosphorus was determined on the clarified extract by the molybdenum blue method.

### **Cation Exchange Capacity**

Was estimated by the methods outlined by Mehlich (1948), in which barium saturation of the soil at pH 8.2 using barium chloride—triethanolamine was followed by displacement of the barium with a calcium chloride solution at a pH of approximately 8. The displaced barium was determined colorimetrically.

### **Total Exchangeable Bases**

The soil was leached with 1 N ammonium acetate solution pH 7, followed by conversion of the acetates of the metal cations in this leachate to carbonates, and titration with standard acid.

### **Individual Cations**

The soil was leached with 1 N ammonium chloride solution and the calcium and magnesium determined by the 'versenate' titration method, while sodium was determined by the flame photometer.

### Available Silica

Was determined by the method of Imaizumi and Yoshida (1958), where 10 g. of air dry soil is extracted with 100 ml. of sodium acetate buffer (pH 4) by maintaining the temperature at 40°C for 5 hours. Silica was determined colorimetrically by the molybdenum blue method.

### Free Iron

The method of Kumada and Asami (1959), was followed in which 0.5 g. of soil is extracted with 3 g. of sodium hydrosulphite in 100 ml. of 0.02 M EDTA solution by maintaining the temperature at 70°C for 15 minutes. Iron was determined colorimetrically by the O-phenanthroline method.

## RESULTS AND DISCUSSION

The location of each sampling site was accurately transferred from each of the 1 inch to a mile topographic sheets on to an island map of 1 : 500,000 scale, and a set of single factor soil maps at this scale was prepared in respect of pH, available phosphorus and exchangeable potassium respectively. Another set of single factor soil maps was prepared in respect of organic matter, nitrogen, cation exchange capacity and soil texture at a scale of 1 : 1,000,000. For the purpose of this publication, all these maps were further generalized and reduced to the form in which they are presented in Maps 2-8 at the end of this text. These generalized maps depict the regional distribution pattern of each of the measured soil characteristics. A more accurate idea of the local variations of these soil characteristics within a district may be had from Table 1, which shows the modal range values of pH, available phosphorus and exchangeable potassium in respect of each D. R. O. division. Table 2 shows the modal range values district-wise in respect of total exchangeable bases, individual cations (excluding potassium), percentage base saturation, free iron and available silica.

In its scope, this publication is limited to a straightforward discussion of the results obtained in respect of each of the measured soil characteristics. A detailed interpretation of these results from the pedological and physico-chemical standpoint would necessarily form the subject of a more specialized paper.

## Soil pH

The characteristic inverse relationship between soil pH and rainfall is clearly borne out in Map 2. It is observed that the rice soils of the low country wet zone are strongly acid in reaction ; and the areas of extremely acid soils also occur within this region.

Soil reaction in the mid country and up country regions is also strongly acid, with the exception of certain sections of the Kandy district which are moderately acid. A transition to increasing pH is observed in the intermediate zone region.

Most of the dry zone rice soils are slightly acid to neutral in reaction. Those developed on the highly weathered coarse alluvium of the coastal plain regions of east and north-east Ceylon are moderately acid in reaction. Rice soils of the western part of Jaffna peninsula and Mannar district are alkaline in reaction. Strongly alkaline rice soils are found to occur mainly on the recent marine clay deposits along the coastal plain of the Mannar district ; the conductivity of the saturated extracts of such soils often exceed 4 milli-mhos/cm., and the sodium saturation of the exchange complex is usually greater than 15 per cent.

It was observed that the pH of the air dry soil was always a few units higher or lower than the pH at field moisture content. In the wet zone, for soils which fall within the pH range of 4.2-6.0 (air dry), the pH of the air dry soil was less than the pH at field moisture content ; and the order of this difference ranged from zero to 1.6 units of pH. On the other hand, in the dry zone, for soils which fall within the pH range of 5.6-8.0 (air dry), the pH of the air dry soil was higher than the pH at field moisture content ; and the order of this difference ranged from zero to 0.8 units of pH.

## Soil Nitrogen and Organic Matter

Because of the intimate relationship which exists between nitrogen and organic matter, these two soil characteristics are discussed together, although for convenience, their regional distribution patterns are shown separately in Maps 3 and 4. It can be observed that the broad distribution patterns in respect of both soil nitrogen and soil organic matter are very similar.

Both nitrogen and organic matter contents of the rice soils are highest in the low-lying regions of the Kalutara and Galle districts which are in the low country wet zone. The C/N ratio for these two

districts as shown in Table 1, is in the range 15-25, which by conventional standards is high. Similarly, the rice soils of the western parts of the Ratnapura district also have a high C/N ratio, although the soil nitrogen content is not correspondingly high. For the rest of the island, it can be observed that both soil nitrogen and organic matter is high to medium in the low country wet zone ; medium in the mid country and up country ; and is low to very low in the dry zone. The C/N ratio is observed to decrease with decreasing rainfall. It has a value of 10-15 in the wet zone and decreases to a value of 8-10 in the dry zone where in certain districts its value is even less than 8.

The above regional trends in soil nitrogen, organic matter and C/N ratio are in general accordance with the governing soil forming factors.

### **Available Soil Phosphorus**

It can be observed in Map 5, that a majority of the island's rice soils are poorly supplied in phosphorus. The areas that have an inherently good supply of soil phosphorus are found to be restricted to the flood plain regions of the Walawe Ganga in the Hambantota district and the Gal Oya in the Amparai district. The high content of available phosphorus in the western part of Jaffna peninsular can be attributed to the traditional application of fertilizers by the farmers. Most of the other areas which analyse either high or medium for available phosphorus are found to occur within the plantation crop districts where phosphate fertilizers have been regularly applied on the highland. It is probable, that fair amounts of phosphate are carried into the valleys along with the erosional wash from the upland.

The present regional distribution pattern of soil phosphorus is likely to change radically within the next decade because of the rapidly increasing use of phosphate fertilizers in rice cultivation.

### **Exchangeable Soil Potassium**

The regional distribution pattern of exchangeable soil potassium is shown in Map 6. When viewed in conjunction with the rainfall and the geological maps of the island, it is found that there is a close relationship between the exchangeable soil potassium and both the leaching intensity as well as parent rock type.

High rainfall is generally correlated with low exchangeable potassium except where the potash rich parent material has a prepondering influence as in parts of the Galle, Matara, Kandy and Nuwara

Eliya districts. Thus, it can be observed that exchangeable soil potassium is generally low in the wet and intermediate zones, while it is medium to high in the dry zone. Soils developed on the coarse alluvium of the coastal plain regions of the dry zone are very low in exchangeable potassium, whereas soils developed on the recent clayey alluvium of the coastal plain region are very high in exchangeable potassium.

### **Soil Cation Exchange Capacity**

The total cation exchange capacity of a rice soil is considered to be one of the most important soil characteristics which influence the yield of rice according to Matsuo (1963), who has observed that the record yields by Japanese farmers have been obtained on soils which have a cation exchange capacity of not less than 22 m.e./100g.

As seen in Map 7, a majority of the island's rice soils have a very satisfactory level of cation exchange capacity. It is observed that values of less than 10 m.e./100g. are usually associated with the moderately coarse to coarse textured rice soils. However, when Map 7 is matched with Map 8, it can be observed that certain areas of moderately fine to fine textured soils also analyse low for cation exchange capacity; this could probably be attributed to a poorly reactive clay mineral type.

### **Nature and Distribution of Individual Cations**

The modal range values for each district in respect of total exchangeable bases, exchangeable calcium, magnesium and sodium and the percentage base saturation is given in Table 2. Rice soils of the Colombo, Kalutara and Galle districts are very low in total exchangeable bases, while those of the Kegalle, Ratnapura and Matara districts are low. The other districts of the wet and intermediate zones have a moderate value. The rice soils of the dry zone districts are well supplied in total exchangeable bases, except in the Batticaloa district where the rice soils developed on the highly weathered coarse alluvium, analyse low for total exchangeable bases.

The modal range values for exchangeable calcium and magnesium show a trend similar to that of the total exchangeable bases. The ratio of exchangeable calcium to magnesium is highly variable, and the nature of this variation cannot be readily interpreted in general terms.

It is observed that the values of exchangeable sodium for the rice soils of the island are appreciably higher than for the upland non-irrigated soils which occur in association with the rice fields. This is not unusual, considering the fact that most rice soils are located in the valleys which receive the leached products of the adjacent residual lands; and the equilibrium distribution of the individual cations within the exchange complex of the rice soils would thus differ from that of the associated upland soil. At the levels of exchangeable sodium which have been reported in Table 2, it seems probable that sodium could be satisfying the nutritional requirements of the rice plant to a certain extent, especially in those rice soil regions where the potassium level of the soil is poor in relation to sodium.

Percentage base saturation is very well correlated with rainfall. It is lowest in the heavy rainfall districts of Kalutara and Colombo, and steadily increases with decreasing rainfall. The percentage base saturation of the rice soils of the dry zone is between 70 to 100 per cent.

### **Free Iron**

The free iron content of rice soils is observed to be highest in the Kandy, Kegalle and Nuwara Eliya districts. The rice fields in these districts are mainly located within the great soil group of the 'Reddish Brown Lateritic Soils' which is also termed 'Ferruginous Tropical Soils' by the French school of soil scientists in Africa. Free iron content of the alkaline rice soils in the Jaffna and Mannar districts is very low.

The very low values of free iron recorded for the rice soils of the Batticaloa district, when viewed in conjunction with their other characteristics seem to indicate that these soils closely approximate the 'Degraded Rice Soils' of Japan.

### **Available Silica**

Assuming a threshold level of 200 lb./acre of available silica as the limit below which the silica requirement of the rice plant will not be satisfied, it can be observed that most rice soils of the Kalutara, Colombo and Batticaloa districts would be deficient in available silica. The analysis of irrigation waters which is presently in progress would reveal the extent to which silica is being supplied by the irrigation water. The supplies of available silica in the rice soils of all other districts are found to be quite adequate.

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FERTILITY CHARACTERISTICS OF THE RICE-GROWING SOILS OF CEYLON

TABLE I—Model Range Values

<i>District and D. R. O. Division</i>	<i>pH</i>	<i>Phos- phorus lb. P<sub>2</sub>O<sub>5</sub> per acre</i>	<i>Potassium m.e.K/100g.</i>	<i>Nitrogen N%</i>	<i>C/N Ratio</i>
<b>1. Jaffna</b>					
(i) Island Division ..	7.3-8.3..	15-30..	>0.30		
(ii) Jaffna Division ..	7.3-8.3..	45-60..	>0.30		
(iii) Valikamam West, North and East Divisions	7.3-8.3..	45-60..	>0.30		
(iv) Tenmaradchi Division ..	7.3-8.3..	15-30..	0.25-0.30		
(v) Vadamaradchchi Divi- sion	7.3-8.3..	15-30..	0.25-0.30		
(vi) Pachchilaippali- Kara- chchi	5.3-5.9..	5-15..	<0.10		
(vii) Punakari-Tunukkai ..	6.6-7.2..	5-15..	>0.30		
District Value ..	6.6-7.2..	15-30..	>0.30..	<0.050..	< 8
<b>2. Vavuniya</b>					
(i) Vavuniya South (Tamil)	6.0-6.5..	5-15..	0.10-0.15		
(ii) Vavuniya South (Sinha- lese)	6.0-6.5..	5-15..	0.10-0.15		
(iii) Vavuniya North ..	6.0-6.5..	5-15..	0.10-0.15		
(iv) Maritime Pattus ..	6.0-6.5..	5-15..	0.25-0.30		
District Value ..	6.0-6.5..	5-15..	0.10-0.15..	0.050-0.100..	8-10
<b>3. Mannar</b>					
(i) Mantai Division ..	6.0-6.5..	5-15..	0.25-0.30		
(ii) Mannar Island Division	7.3-8.3..	5-15..	>0.30		
(iii) Musali Division ..	7.3-8.3..	5-15..	>0.30		
District Value ..	7.3-8.3..	5-15..	>0.30..	0.050-0.100..	< 8
<b>4. Trincomalee</b>					
(i) Koddiyar Pattu	5.3-5.9..	15-30..	<0.10		
(ii) Tampalakamam Pattu Trincomalee Town & Gravets Division	6.6-7.2..	0- 5..	0.10-0.15		
(iii) Kaddukulam Pattu ..	6.6-7.2..	0- 5..	0.10-0.15		
District Value ..	6.6-7.2..	0- 5..	0.10-0.15..	0.101-0.150..	8-10
<b>5. Anuradhapura</b>					
(i) Nuwaragam Palata West	6.0-6.5..	5-15..	>0.30		
(ii) Nuwaragam Palata East	6.6-7.2..	5-15..	0.15-0.20		
(iii) Hurulu Palata ..	6.0-6.5..	5-15..	0.15-0.20		
(iv) Kalagam Palata ..	6.0-6.5..	15-30..	0.15-0.20		
District Value ..	6.0-6.5..	5-15..	0.15-0.20..	0.050-0.100..	10-15

TROPICAL AGRICULTURIST, VOL. CXX, 1964

<i>District and D. R. O. Division</i>	<i>pH</i>	<i>Phos- phorus lb. P<sub>2</sub>O<sub>5</sub> per acre</i>	<i>Potassium m.e.K/100g.</i>	<i>Nitrogen N%</i>	<i>C/N Ratio</i>
<b>6. Puttalam</b>					
(i) Puttalam Pattu & Gravets	4.5-5.2..	5-15..	0.25-0.30		
(ii) Demala Hatpattuwa ..	6.0-6.5..	5-15..	0.20-0.25		
(iii) Pitigal Korale North ..	4.5-5.2..	15-30..	<0.10		
(iv) Pitigal Korale South	4.5-5.2..	15-30..	<0.10		
District Value ..	4.5-5.2..	5-15..	0.20-0.25..	0.050-0.100..	10-15
<b>7. Polonnaruwa</b>					
(i) P. S. S., Minneriya & Giritale Schemes	6.5-7.2..	5-15..	<0.10		
(ii) Elahera Scheme ..	6.0-6.5..	15-30..	0.10-0.15		
District Value ..	6.0-6.5..	15-30..	0.10-0.15..	0.050-0.100..	10-15
<b>8. Batticaloa</b>					
(i) Eruvil Porativu and Manmunai Pattu South	5.3-5.9..	5-15..	<0.10		
(ii) Manmunai Pattu North	5.3-5.9..	5-15..	<0.10		
(iii) Eravur and Koralai Pattus	5.3-5.9..	5-15..	0.10-0.15		
District Value ..	5.3-5.9..	5-15..	<0.10..	0.050-0.100..	<8
<b>9. Matale</b>					
(i) Matale South ..	5.3-5.9..	30-45..	0.10-0.15		
(ii) Matale East ..	5.3-5.9..	30-45..	0.10-0.15		
(iii) Matale North ..	6.0-6.5..	5-15..	<0.10		
District Value ..	5.3-5.9..	5-15..	0.10-0.15..	0.101-0.150..	10-15
<b>10. Kurunegala</b>					
(i) Wannu Hatpattuwa ..	6.0-6.5..	5-15..	0.15-0.20		
(ii) Hiriyala Hatpattuwa ..	6.0-6.5..	5-15..	<0.10		
(iii) Weudawili Hatpattuwa	5.3-5.9..	15-30..	0.10-0.15		
(iv) Dambadeni Hatpattuwa	4.5-5.2..	15-30..	<0.10		
(v) Dewamedi Hatpattuwa	6.0-6.5..	5-15..	<0.10		
(vi) Katugampola Hatpattuwa	4.5-5.2..	5-15..	<0.10		
District Value ..	5.3-5.9..	5-15..	0.10-0.15..	0.050-0.100..	8-10
<b>11. Badulla</b>					
(i) Bintenna Division ..	6.0-6.5..	5-15..	<0.10		
(ii) Wiyaluwa Division ..	4.5-5.2..	30-45..	0.10-0.15		
(iii) Udukinda Division ..	4.5-5.2..	15-30..	0.10-0.15		
(iv) Yatikinda Division ..	4.5-5.2..	15-30..	0.10-0.15		
District Value ..	4.5-5.2..	15-30..	0.10-0.15..	0.151-0.250..	10-15

THE FERTILITY CHARACTERISTICS OF THE RICE-GROWING SOILS OF CEYLON

<i>District and D. R. O. Division</i>	<i>pH</i>	<i>Phos- phorus lb. P<sub>2</sub>O<sub>5</sub> per acre</i>	<i>Potassium m.e.K/100g.</i>	<i>Nitrogen N%</i>	<i>C/N Ratio</i>
<b>12. Amparai</b>					
(i) Panama Pattu ..	5.3-5.9..	15-30..	>0.30		
(ii) Akkarai Pattu ..	6.6-7.2..	5-15..	0.10-0.15		
(iii) Karavaku and Nintavur Pattus	5.3-5.9..	45-60..	0.10-0.15		
(iv) Sammanturai Pattu ..	5.3-5.9..	15-30..	0.10-0.15		
(v) Bintenna Pattu ..	4.5-5.2..	30-45..	0.15-0.20		
(vi) Wewgam Pattu ..	5.3-5.9..	5-15..	<0.10		
District Value ..	5.3-5.9..	15-30..	0.10-0.15..	0.050-0.100..	8-10
<b>13. Kegalle</b>					
(i) Galboda and Kinigoda Korales	4.5-5.2..	15-30..	0.10-0.15		
(ii) Paranakuru Korale ..	4.5-5.2..	15-30..	<0.10		
(iii) Beligal Korale ..	4.5-5.2..	15-30..	<0.10		
(iv) Dehigampal Korale and Lower Bulatgama	4.5-5.2..	15-30..	<0.10		
(v) Atulugam and Panawal Korale	4.5-5.2..	15-30..	<0.10		
District Value ..	4.5-5.2..	15-30..	<0.10..	0.101-0.150..	10-15
<b>14. Kandy</b>					
(i) Udunuwara and Yati- nuwara Divisions	4.5-5.2..	15-30..	0.10-0.15		
(ii) Tumpane ..	4.5-5.2..	30-45..	0.10-0.15		
(iii) Harispattuwa ..	4.5-5.2..	30-45..	0.10-0.15		
(iv) Pata Dumbara ..	4.5-5.2..	30-45..	0.10-0.15		
(v) Uda Dumbara ..	5.3-5.9..	30-45..	0.10-0.15		
(vi) Kandy and Pata Hewa- heta Divisions	5.3-5.9..	30-45..	0.10-0.15		
(vii) Uda Palata ..	4.5-5.2..	15-30..	0.15-0.20		
(viii) Uda Bulatgama ..	4.5-5.2..	15-30..	<0.10		
District Value ..	4.5-5.2..	30-45..	0.10-0.15..	0.101-0.150..	10-15
<b>15. Nuwara Eliya</b>					
(i) Kotmale ..	4.5-5.2..	15-30..	0.20-0.25		
(ii) Uda Hewaheta ..	5.3-5.9..	45-60..	0.10-0.15		
(iii) Waalpane ..	5.3-5.9..	15-30..	0.10-0.15		
District Value ..	5.3-5.9..	30-45..	0.10-0.15..	0.101-0.150..	10-15
<b>16. Colombo</b>					
(i) Hapitigam Korale ..	4.5-5.2..	15-30..	<0.10		
(ii) Alutkuru Korale North (A), North (B) and South	4.5-5.2..	15-30..	<0.10		
(iii) Siyane Korale West (AP), West (MP) and East	4.5-5.2..	15-30..	<0.10		

TROPICAL AGRICULTURIST, VOL. CXX, 1964

<i>District and D. R. O. Division</i>	<i>pH</i>	<i>Phos- phorus lb. P<sub>2</sub>O<sub>5</sub> per acre</i>	<i>Potassium m.e.K/100g.</i>	<i>Nitrogen N%</i>	<i>C/N Ratio</i>
(iv) Hewagam Korale ..	4.5-5.2..	15-30..	<0.10		
(v) Salpiti Korale ..	4.5-5.2..	15-30..	<0.10		
(vi) Colombo Mudly. Division	4.5-5.2..	15-30..	<0.10		
District Value ..	4.5-5.2..	15-30..	<0.10..	0.151-0.250..	10-15
<b>17. Ratnapura</b>					
(i) Kuruwiti Korale ..	4.5-5.2..	15-30..	<0.10		
(ii) Nawadun Korale ..	4.5-5.2..	15-30..	<0.10		
(iii) Kukul Korale ..	4.5-5.2..	5-15..	<0.10		
(iv) Kolonna Korale ..	5.3-5.9..	5-15..	0.10-0.15		
(v) Atakalan Korale ..	5.3-5.9..	5-15..	<0.10		
(vi) Kadawata and Meda Korales	4.5-5.2..	15-30..	<0.10		
District Value ..	4.5-5.2..	15-30..	<0.10..	0.151-0.250..	15-25
<b>18. Moneragala</b>					
(i) Wellassa Division ..	5.3-5.9..	5-15..	<0.10		
(ii) Buttala Division ..	6.0-6.5..	5-15..	<0.10		
(iii) Wellawaya Division ..	6.0-6.5..	5-15..	<0.10		
District Value ..	5.3-5.9..	5-15..	<0.10..	0.101-0.150..	<8
<b>19. Kalutara</b>					
(i) Rayigam Korale ..	4.5-5.2..	15-30..	<0.10		
(ii) Kalutara Totamune ..	4.5-5.2..	15-30..	<0.10		
(iii) Panadura Totamune ..	4.5-5.2..	15-30..	<0.10		
(iv) Pasdun Korale West and East	4.5-5.2..	15-30..	<0.10		
District Value ..	4.5-5.2..	15-30..	<0.10..	0.151-0.250..	15-25
<b>20. Galle</b>					
(i) Bentota Walallawiti Korale	4.5-5.2..	15-30..	<0.10		
(ii) Wellaboda Pattuwa ..	4.5-5.2..	15-30..	<0.10		
(iii) Four Gravets ..	4.5-5.2..	15-30..	0.25-0.30		
(iv) Talpe Pattuwa ..	4.5-5.2..	5-15..	0.20-0.25		
(v) Gangaboda Pattuwa ..	4.5-5.2..	15-30..	<0.10		
(vi) Hinidum Pattuwa ..	4.5-5.2..	15-30..	<0.10		
District Value ..	4.5-5.2..	15-30..	<0.10..	0.151-0.250..	15-25
<b>21. Hambantota</b>					
(i) Giruwa Pattu West ..	5.3-5.9..	15-30..	0.10-0.15		
(ii) Giruwa Pattu East ..	6.0-6.5..	15-30..	0.25-0.30		
(iii) Magam Pattuwa ..	6.0-6.5..	45-60..	<0.30		
District Value ..	6.0-6.5..	15-30..	0.25-0.30..	0.101-0.150..	10-15

FERTILITY CHARACTERISTICS OF THE RICE-GROWING SOILS OF CEYLON

<i>District and D. R. O. Division</i>	<i>pH</i>	<i>Phos- phorus lb. P<sub>2</sub>O<sub>5</sub> per acre</i>	<i>Potassium m.e.K/100g.</i>	<i>Nitrogen N%</i>	<i>O/N Ratio</i>
<b>22. Matara</b>					
(i) Morawak Korale ..	4.5-5.2..	5-15..	<0.10		
(ii) Kandaboda Pattuwa ..	4.5-5.2..	5-15..	<0.10		
(iii) Gangaboda Pattuwa ..	4.5-5.2..	5-15..	0.10-0.15		
(iv) Weligam Korale ..	4.5-5.2..	5-15..	0.10-0.15		
(v) Wellaboda Pattuwa and Four Gravets	4.5-5.2..	15-30..	0.20-0.25		
District Value ..	4.5-5.2..	5-15..	0.10-0.15..	0.151-0.250..	10-15

TABLE—2

<i>District</i>	<i>Modal Range Values</i>						
	<i>T.E.B. m.e./100g.</i>	<i>Exchangeable</i>			<i>Base Satura- tion %</i>	<i>Free Iron Fe %</i>	<i>Available Silica lb./acre</i>
		<i>Ca</i>	<i>Mg (m.e./100g.)</i>	<i>Na</i>			
1. Jaffna ..	>15.0	6-10	6.0	0.6-1.0	70-100	0.0-0.5	>600
2. Vavuniya ..	10.1-15.0	6-10	3.1-6.0	0.6-1.0	70-100	0.6-1.0	>600
3. Mannar ..	>15.0	>10	>6.0	>1.0	50-70	0.0-0.5	>600
4. Trincomalee ..	10.1-15.0	6-10	>6.0	0.6-1.0	70-100	0.6-1.0	450-600
5. Anuradhapura	10.1-15.0	6-10	>6.0	0.6-1.0	70-100	1.1-1.5	>600
6. Puttalam ..	6.1-10.0	2-6	>6.0	0.6-1.0	50-70	1.1-1.5	300-450
7. Polonnaruwa..	6.1-10.0	2-6	3.1-6.0	0.6-1.0	70-100	1.1-1.5	>600
8. Batticaloa ..	3.1-6.0	2-6	0.6-1.0	0.6-1.0	70-100	0.0-0.5	100-200
9. Matale ..	6.1-10.0	2-6	3.1-6.0	0.6-1.0	50-70	1.6-2.5	450-600
10. Kurunegala ..	6.1-10.0	2-6	3.1-6.0	0.6-1.0	70-100	0.6-1.0	450-600
11. Badulla ..	6.1-10.0	2-6	1.1-3.0	0.6-1.0	50-70	1.6-2.5	300-450
12. Amparai ..	10.1-15.0	2-6	3.1-6.0	0.6-1.0	70-100	0.6-1.0	450-600
13. Kegalle ..	3.1-6.0	2-6	1.1-3.0	0.6-1.0	30-50	>2.5	450-600
14. Kandy ..	6.1-10.0	2-6	3.1-6.0	0.6-1.0	30-50	>2.5	>600
15. Nuwara Eliya	6.1-10.0	2-6	1.1-3.0	<0.4	15-30	>2.5	>600
16. Colombo ..	0.0-3.0	1-2	1.1-3.0	0.5-0.6	0-15	1.1-1.5	100-200
17. Ratnapura ..	3.1-6.0	2-6	1.1-3.0	0.5-0.6	30-50	1.6-2.5	300-450
18. Moneragala ..	6.1-10.0	2-6	1.1-3.0	0.5-0.6	70-100	1.1-1.5	>600
19. Kalutara ..	0.0-3.0	0-1	0.6-1.0	0.4-0.5	0-15	1.1-1.5	100-200
20. Galle ..	0.0-3.0	2-6	0.0-0.5	0.4-0.5	15-30	1.6-2.5	300-450
21. Hambantota ..	>15.0	>10	>6.0	0.6-1.0	70-100	1.6-2.5	450-600
22. Matara ..	3.1-6.0	1-2	1.1-3.0	0.4-0.5	15-30	1.6-2.5	300-450

MAP 1

DISTRIBUTION OF RICE FIELDS,  
THE MAJOR AGROCLIMATIC ZONES  
AND PRESENT ADMINISTRATIVE DISTRICTS

MILES 0 1 2 3 4 5 6 7 8 9 10 SCALE 10 20 30 40 50 60 70 80 90 100 MILES

REFERENCE

- DRY ZONE D.Z
- INTERMEDIATE ZONE I.Z
- WET ZONE W.Z
- ZONAL BOUNDARY
- DISTRICT BOUNDARIES
- RICE FIELDS



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LAND USE DIVISION, KUNDASALE

Note - The administrative districts are  
numbered in accordance with  
the text

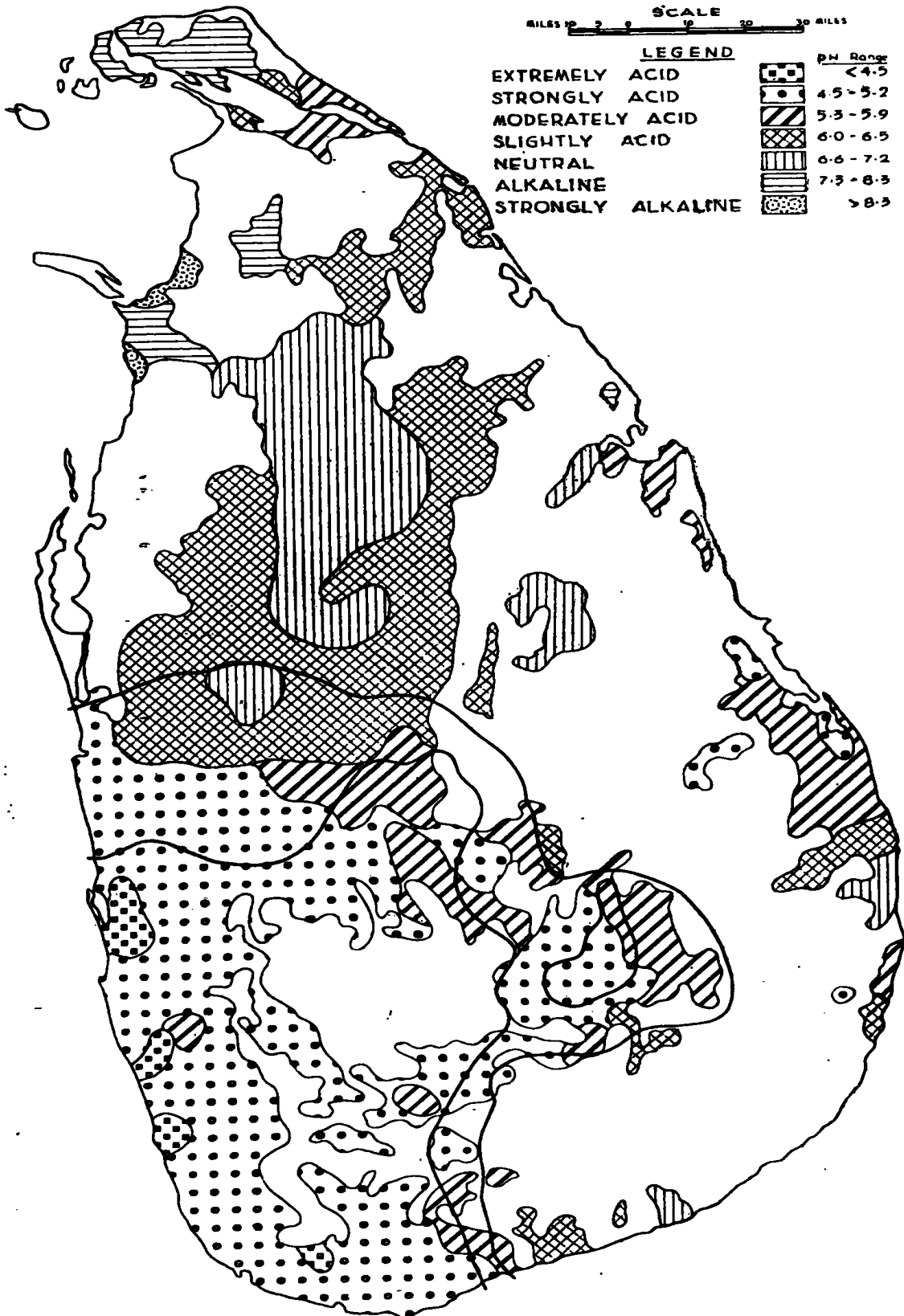
MAP 2

### REGIONAL DISTRIBUTION PATTERN OF SOIL PH

SCALE  
MILES 0 10 20 30

#### LEGEND

	pH Range
EXTREMELY ACID	< 4.5
STRONGLY ACID	4.5 - 5.2
MODERATELY ACID	5.3 - 5.9
SLIGHTLY ACID	6.0 - 6.5
NEUTRAL	6.6 - 7.2
ALKALINE	7.3 - 8.3
STRONGLY ALKALINE	> 8.5









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LAND USE DIVISION, KUNDASALE.

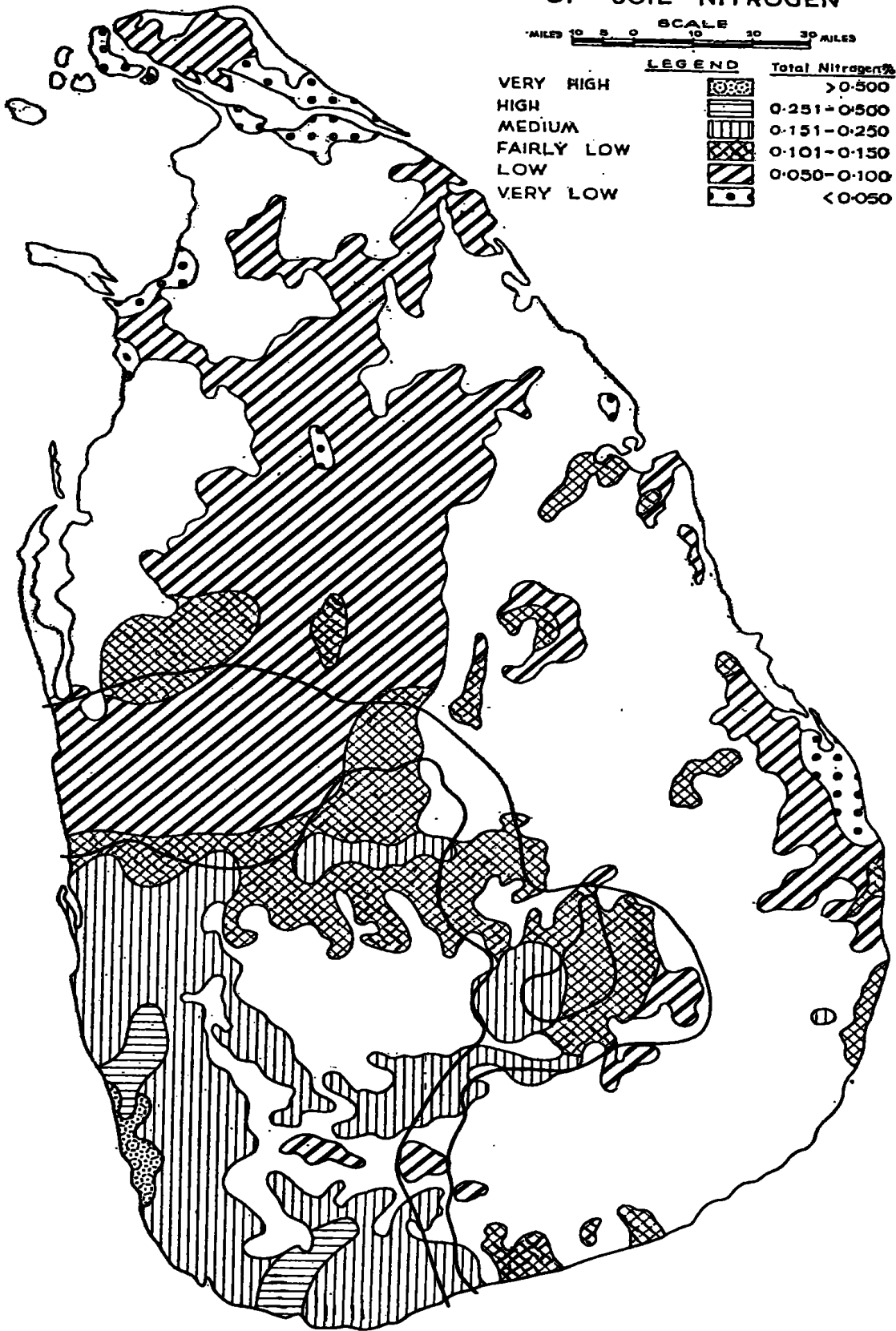
Based on the work carried out by:  
B.L.Fernando, M.S.M.Marzook, L.B.Michael,  
S.O.J.de Silva & T.Thangavadivel.

MAP 3

### REGIONAL DISTRIBUTION PATTERN OF SOIL NITROGEN

SCALE  
MILES 10 20 30

	LEGEND	Total Nitrogen%
VERY HIGH		>0.500
HIGH		0.251-0.500
MEDIUM		0.151-0.250
FAIRLY LOW		0.101-0.150
LOW		0.050-0.100
VERY LOW		<0.050



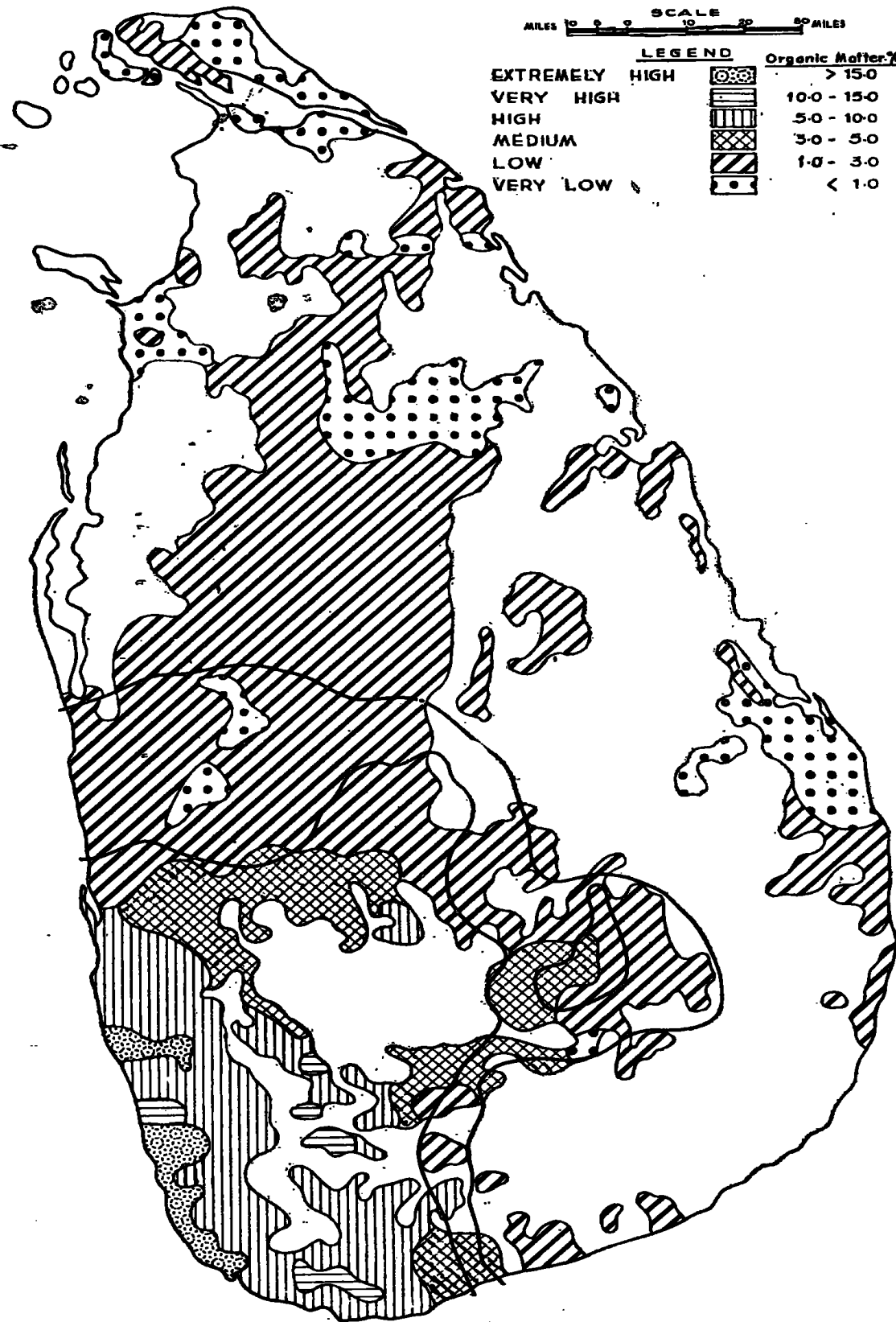
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LAND USE DIVISION, KUNDASALE.

Chemical analysis by  
M Sathkunawathy & T B Gamaqedara

REGIONAL DISTRIBUTION PATTERN  
OF SOIL ORGANIC MATTER

SCALE  
MILES 0 10 20 30 40 50 MILES

LEGEND		Organic Matter%
EXTREMELY HIGH		> 15.0
VERY HIGH		10.0 - 15.0
HIGH		5.0 - 10.0
MEDIUM		3.0 - 5.0
LOW		1.0 - 3.0
VERY LOW		< 1.0








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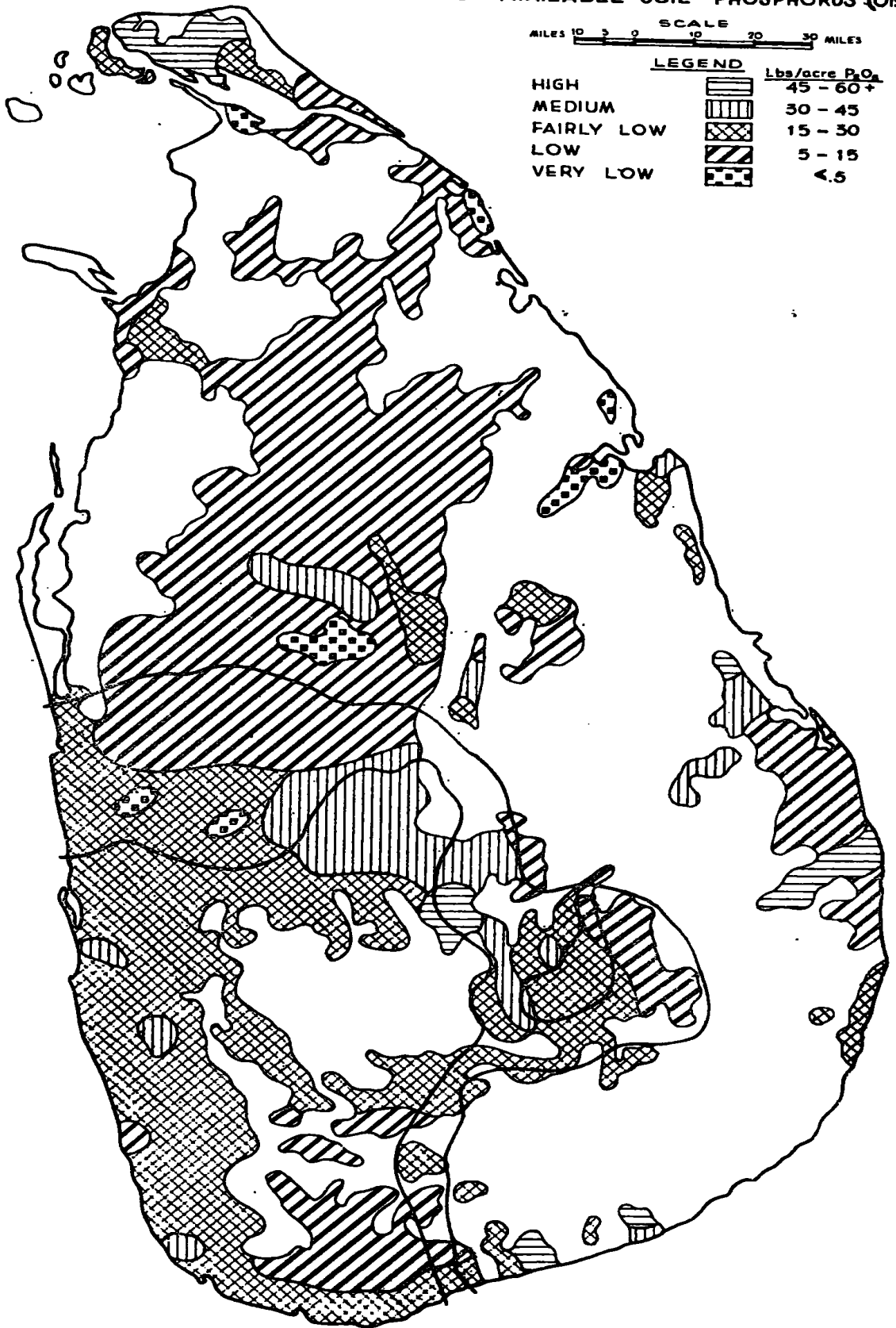
Chemical analysts by:  
J. Pelpola, B.L. Fernando, T. Thangavadivel,  
& R.B. Keenapitiya.

MAP 5

REGIONAL DISTRIBUTION PATTERN OF AVAILABLE SOIL PHOSPHORUS (Olsen)

SCALE  
MILES 10 20 30 MILES

LEGEND		Lbs/acre $P_2O_5$
HIGH		45 - 60+
MEDIUM		30 - 45
FAIRLY LOW		15 - 30
LOW		5 - 15
VERY LOW		< 5









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LAND USE DIVISION, KUNDASALE.

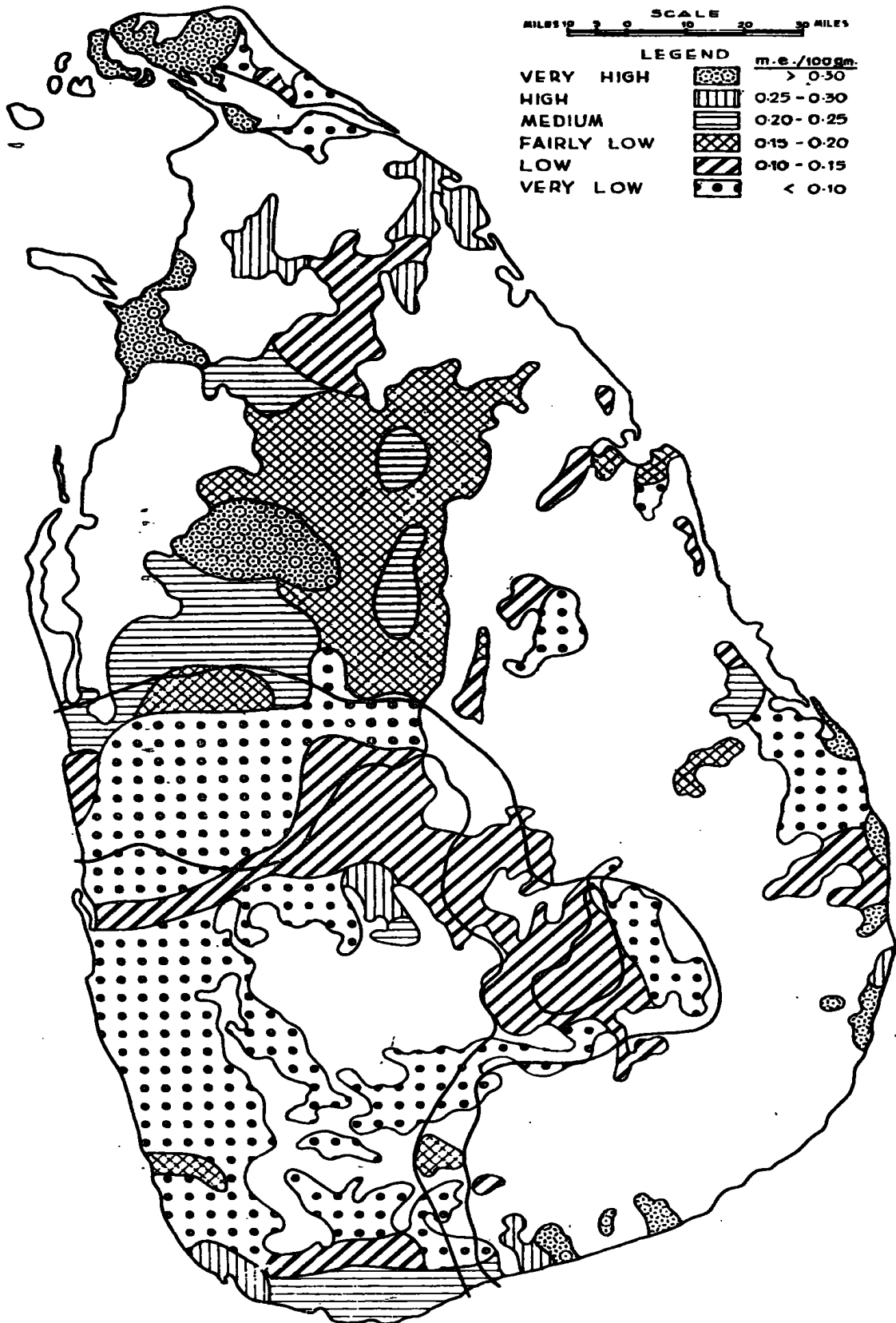
Based on soil analysis carried out by:  
U.T. Aturupana, H. Dissanayaka, T.B. Gamagedera,  
R.B. Keerapitiya, O.T.B. Perera & S.M. Willenberg.

MAP 6

### REGIONAL DISTRIBUTION PATTERN OF EXCHANGEABLE SOIL POTASSIUM

SCALE  
MILES 0 10 20 30

	LEGEND	m.e./100gm.
VERY HIGH		> 0.30
HIGH		0.25 - 0.30
MEDIUM		0.20 - 0.25
FAIRLY LOW		0.15 - 0.20
LOW		0.10 - 0.15
VERY LOW		< 0.10








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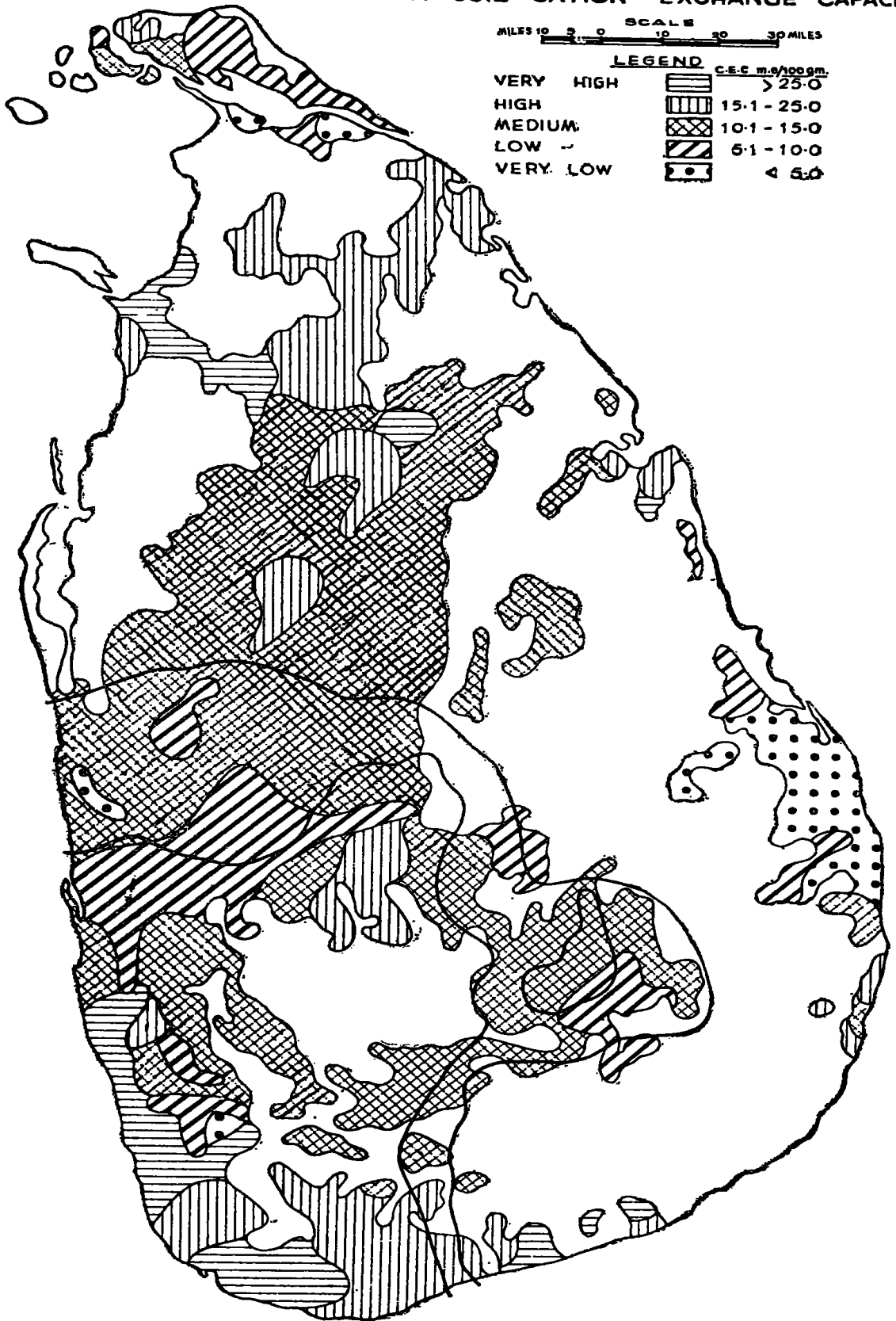
Based on soil analysis carried out by:  
U.T. Aturupana, H. Dissanayaka, T.B. Gamagedera  
R.B. Keenapitiya, O.T.B. Perera & S.M. Willenberg.

MAP 7

### REGIONAL DISTRIBUTION PATTERN OF SOIL CATION EXCHANGE CAPACITY

SCALE  
MILES 0 10 20 30

	LEGEND	C.E.C. m.e./100g.
VERY HIGH		> 25.0
HIGH		15.1 - 25.0
MEDIUM		10.1 - 15.0
LOW		5.1 - 10.0
VERY LOW		< 5.0



DRAWN BY K. S. FERNANDO, CARTOGRAPHER,  
LAND USE DIVISION, KUNDASALE




Chemical analysis by  
S. Sivasubramanian

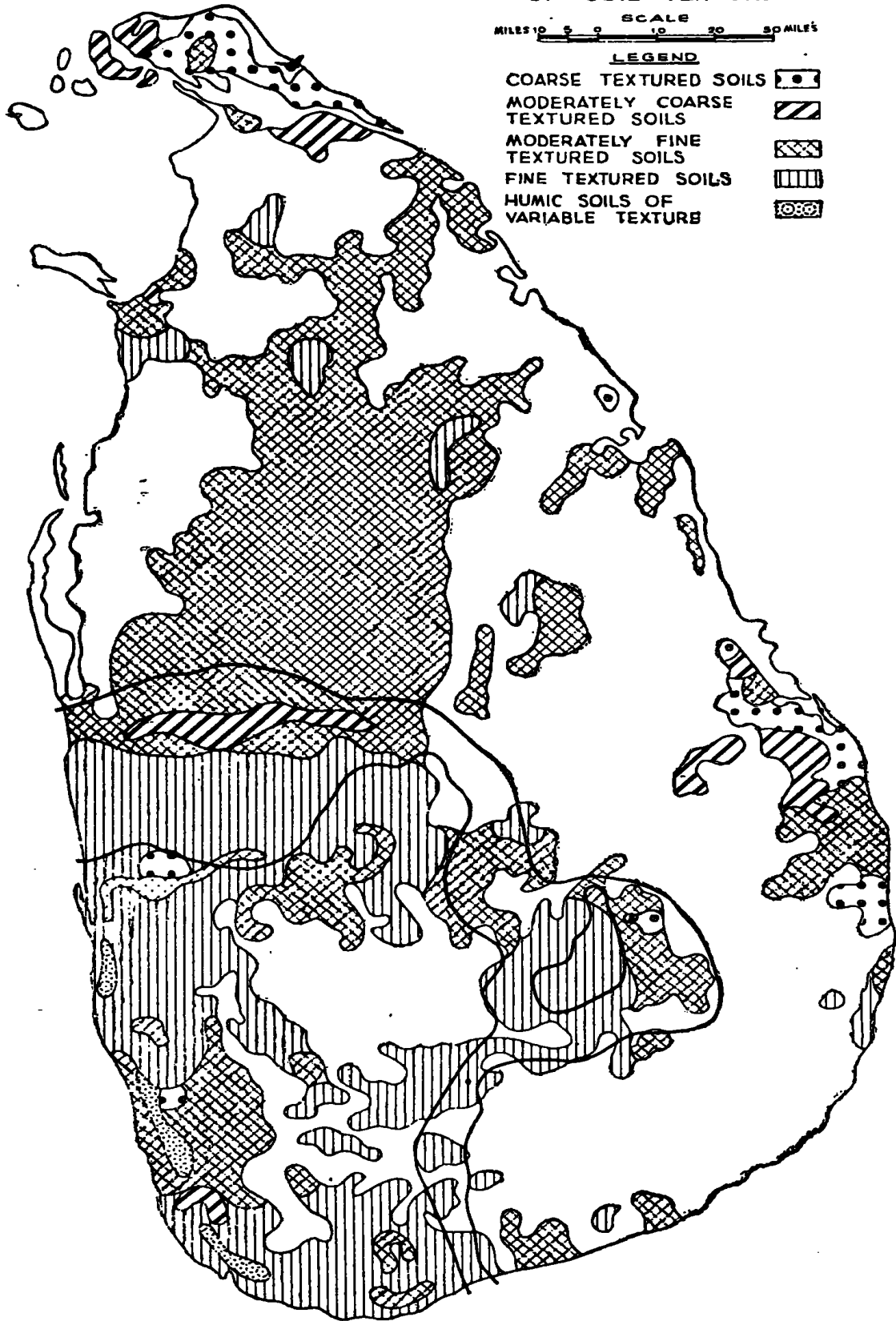
MAP 8

### REGIONAL DISTRIBUTION PATTERN OF SOIL TEXTURE

SCALE  
MILES 0 5 10 20 30 MILES

LEGEND

- COARSE TEXTURED SOILS 
- MODERATELY COARSE TEXTURED SOILS 
- MODERATELY FINE TEXTURED SOILS 
- FINE TEXTURED SOILS 
- HUMIC SOILS OF VARIABLE TEXTURE 



DRAWN BY: K.S.FERNANDO, CARTOGRAPHER  
LAND USE DIVISION, KUNDASALE

Based on the field investigations carried out by  
Messrs. B.L.Fernando, L.B.Michael, M.S.M.Mcraob,  
S.O.J.de Silva & T.Thangavadivel.