

# AN EVALUATION OF THE NUTRIENT STATUS OF THE RUBBER SOILS OF CEYLON

By

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## INTRODUCTION

Since the establishment of the Rubber Research Scheme Ceylon in 1913, the Soils Chemistry Department of the Institute has been working on the fertilizer requirements of rubber. Up to the present day, fertilizer needs of rubber in Ceylon have been largely evaluated by the usual classical techniques of field experimentation, using different levels of the elements studied. Much of today's recommendations of the major nutrients, nitrogen, phosphorus, potash and magnesium have been the result of findings from field experiments, which were pioneered by Constable and continued by Jeevaratnam. Field experiments by the very nature of their execution, are time-consuming and costly. Besides, the ever increasing cost of fertilizer and the highly competitive rubber market, made it imperative that a less expensive and quicker evaluation of the fertilizer needs of the industry was made available. With this objective in view, the identification and mapping of the rubber soils was initiated in 1963. This work which was completed by Silva in 1968, has made it possible for the existing recommendations to be implemented meaningfully. The work reported in this paper is essentially a follow up of the work started in 1963 and is aimed at evaluating our soil resources, and grouping these soils according to their ability to yield, for the purpose of ideal management and maximum production.

## MATERIALS AND METHODS

Thirty sites were sampled for each soil series (Silva, 1968), ten auger samples being taken from the two depths, 0—6" and 6—18", at each site and made into two composite samples thus giving sixty samples. In selecting a sampling site the manuring circle was avoided. The area of sampling was about  $\frac{1}{4}$  acre, for each site.

Reserve potassium and phosphorus were determined using a concentrated HCl extract of the soil as described by Piper (1950). Exchangeable calcium and magnesium and the cation exchange capacities of these soils were determined using ammonium acetate, as described by Piper. Total soil nitrogen was determined using the Kjeldahl method; organic carbon was determined using the wet combustion method suggested by Walkley & Black (1934). Soil reaction was measured using a Beckman portable pH meter and a soil/water ratio of 1 : 2.5.

Seven soil series were identified by Silva (1968), *viz.* Parambe, Matale, Agalawatta, Homagama, Boralu, Ratnapura and Deniya soil series. The Deniya and Ratnapura series, have not been included in this study because both these series have a small acreage and the latter shows properties very similar to the Agalawatta series.

The nomenclature has been according to accepted principles : while Homagama and Boralu are names used by earlier workers for similar soils, Matale, Parambe and Agalawatta, derive their names either because the particular soil series was located first in that place or is most predominant in that locality.

### RESULTS

The soils of about 2,250 square miles in the South Western part of Ceylon have been surveyed. A very large percentage of Ceylon rubber is found in this surveyed area. The rubber lands in the Moneragala and Passara areas have not been covered in this survey.

Table 1 gives the acreages of each soil series that we have been able to locate in smallholdings and estates separately. The assistance received from the Institute's extension staff was very valuable in the process of estimating the acreages of smallholders' rubber. The task of locating estate rubber lands specially those between 10 acres and 100 acres was difficult. As a result, only 201,802 acres out of about 400,000 acres have been located.

TABLE 1

#### ACREAGES OF DIFFERENT SOILS UNDER RUBBER IN CEYLON

Soil series	Smallholdings		Estates	
	Acreage	% of area surveyed	Acreage	% of area surveyed
Boralu	64,059	51	87,184	43
Agalawatta	23,295	18	34,730	17
Homagama	18,915	15	53,760	27
Parambe	17,998	14	22,704	11
Ratnapura	1,718	0.1	1,754	1.9
Matale	48	0.03	1,670	0.8
Total	126,033	98.13	201,802	99.7

**POTASSIUM P.P.M.**

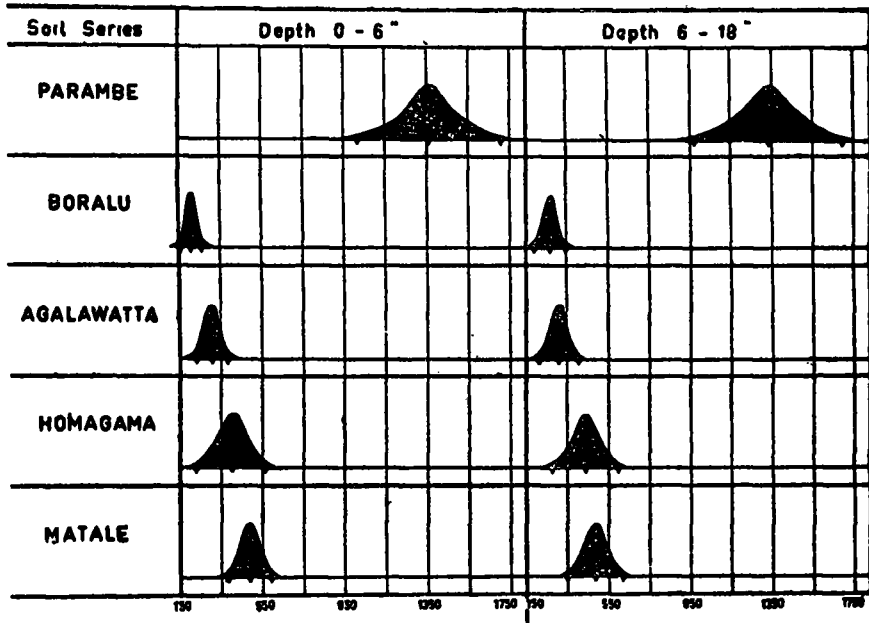


Fig. 1

**PHOSPHORUS P.P.M.**

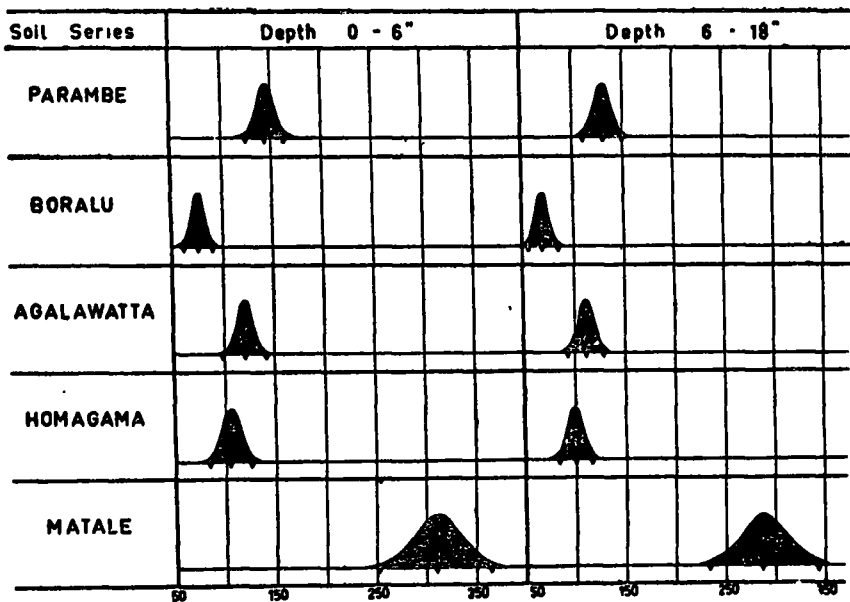


Fig. 2

Ranges for nutrient contents in soil samples from the different soil series

### Exchangeable Ca

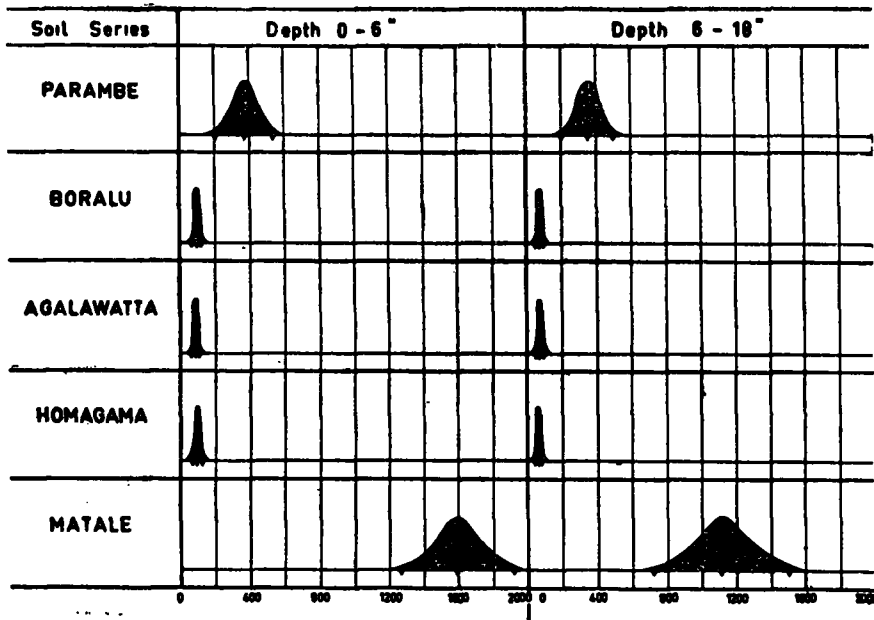


Fig. 3

### Exchangeable Mg

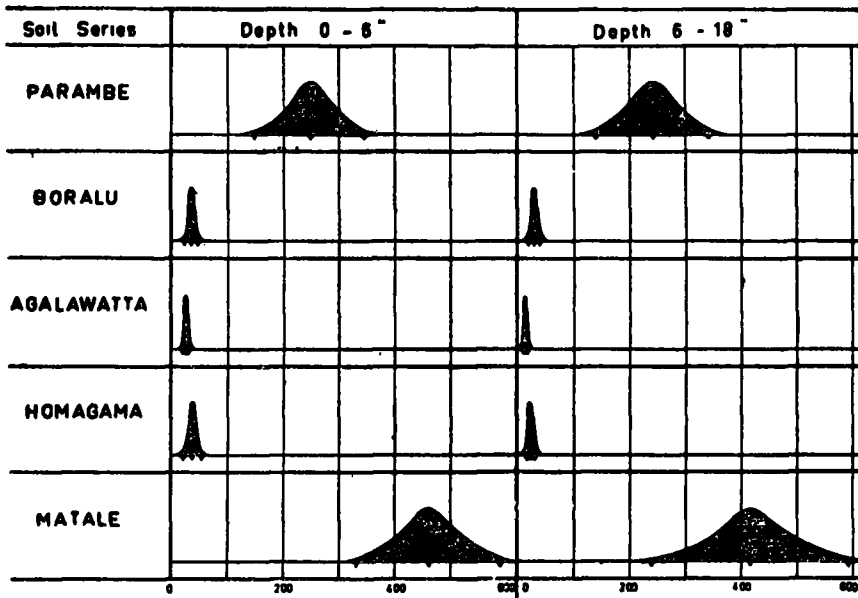


Fig. 4

Ranges for nutrient contents in soil samples from the different soil series

Of the areas that have been located in smallholdings, 51% belong to the Boralu series, while 18%, 15% and 14% are of the Agalawatta, Homagama and Parambe series, respectively. When estates over ten acres in extent are considered, it is seen that 43% belong to the Boralu series while 27%, 17% and 11% are of the Homagama, Agalawatta and Parambe series, respectively.

#### *Reserve potassium*

Reserve potassium is highest in the Parambe series, being almost equally distributed at both depths. The next highest is in the Matale series but the amounts are less than half that of the Parambe series, *i.e.* 1369 and 1338 for the top soil and sub-soil, respectively, in Parambe, compared to 487 and 483 in the Matale series. Next comes Homagama (393 and 446), Agalawatta (312 and 317) and lastly Boralu (207 and 273). Fig. 1 while showing these differences also indicates that for Parambe and Matale the range is large, while for the other soil series it is very narrow. This shows to a certain extent the homogeneity with regard to this property in the Agalawatta, Homagama and Boralu soil series.

#### *Reserve phosphorus*

Phosphorus amounts are highest in the Matale series (308 and 290) followed by the Parambe series (144 and 131), Agalawatta (120 and 110), Homagama (103 and 100) and lastly Boralu (77 and 71). Fig. 2 shows the diagrammatic representation for each series. The homogeneity of the Agalawatta, Homagama and Boralu series when compared to Matale and Parambe is also seen here, but to a lesser extent.

#### *Exchangeable calcium*

The exchangeable calcium values are considered next. The pattern here is similar to that for phosphorus, in that it is highest in the Matale series which has 1598 and 1115 ppm of calcium. This property however differs in that the Boralu and Homagama values are almost the same. The Agalawatta series contains the least amounts of calcium. Fig. 3 shows that the range in this value is also great where the values are high, as in the Matale and Parambe series, and narrow in the other three series.

#### *Exchangeable magnesium*

The exchangeable magnesium values are highest in the Matale series which has 461 ppm and 416 ppm of magnesium at the two depths. This of course is quite understandable because the Matale series soils are derived from dolomitic limestone which is rich in both calcium and magnesium. The exchangeable magnesium values in the Homagama and Boralu soils are almost the same being 96 and 97 for the 0—6" layer and 55 and 61 for the 6—18" layer. The Agalawatta series soil contains the least amounts of magnesium.

#### *Total nitrogen*

The total nitrogen values given in Fig. 5 show that the Matale series has the highest amounts of total nitrogen (0.174% and 0.102%) followed by Agalawatta (0.117% and 0.091%) and Homagama (0.118% and 0.078%) which have similar amounts. Next comes Parambe (0.092% and 0.06%) and lastly Boralu (0.071% and 0.048%).

### *Organic carbon*

The organic carbon values are given in Fig. 6 and represent the range and the levels in each series for the two depths. This property follows a pattern similar to the nitrogen pattern, except that the organic carbon content of the Parambe series is the lowest.

### *Cation exchange capacity*

The cation exchange capacity was determined only from 15 sites of each series instead of the usual 30 sites. Fig. 7 shows that the Matale series has the highest values (9.9 and 8.9). The next highest is in Parambe (5.50 and 5.34) followed by Agalawatta (3.28 and 2.58), Homagama (3.15 and 3.03) and lastly Boralu (2.97 and 2.67).

### *Soil reaction*

The pH values given in Fig. 8, show that all these soils are acidic. The Matale series has a pH close to neutral (6.07 and 5.93). The Homagama series is the most acidic (4.69 and 4.64) while Parambe (5.35 and 5.37), Boralu (5.33 and 5.29) and Agalawatta (5.01 and 5.05) are intermediate.

### (1) *Mechanical analysis*

The mechanical analysis of these soils are given in Table 2.

TABLE 2

PARTICLE SIZE DISTRIBUTION VALUES

Soil series	Coarse sand %	Fine sand %	Silt %	Clay %
Matale series	42.71	34.32	6.02	11.42
	33.76	34.49	9.25	16.43
Parambe series	39.18	19.90	7.83	30.95
	35.91	17.96	10.56	32.96
Agalawatta series	47.21	17.89	4.54	26.62
	44.68	20.27	4.75	27.44
Homagama series	55.11	13.73	10.02	20.16
	52.79	13.39	11.44	22.56
Boralu series	49.11	19.75	5.19	23.64
	42.24	23.31	9.23	22.83

## TOTAL NITROGEN PERCENTAGE

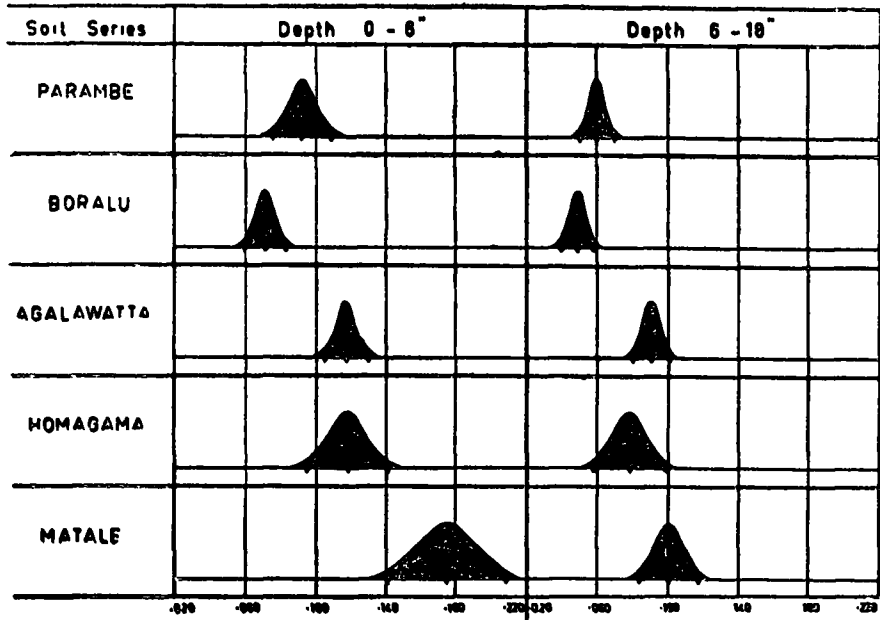


Fig. 5

## Soil Carbon

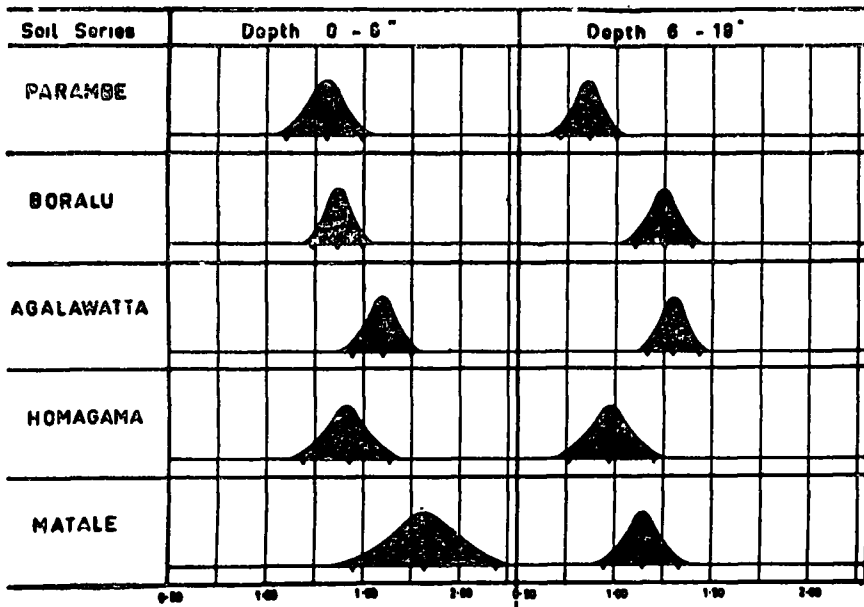


Fig. 6

Ranges for the nitrogen and carbon in soil samples from the different soil series

## CATION EXCHANGE

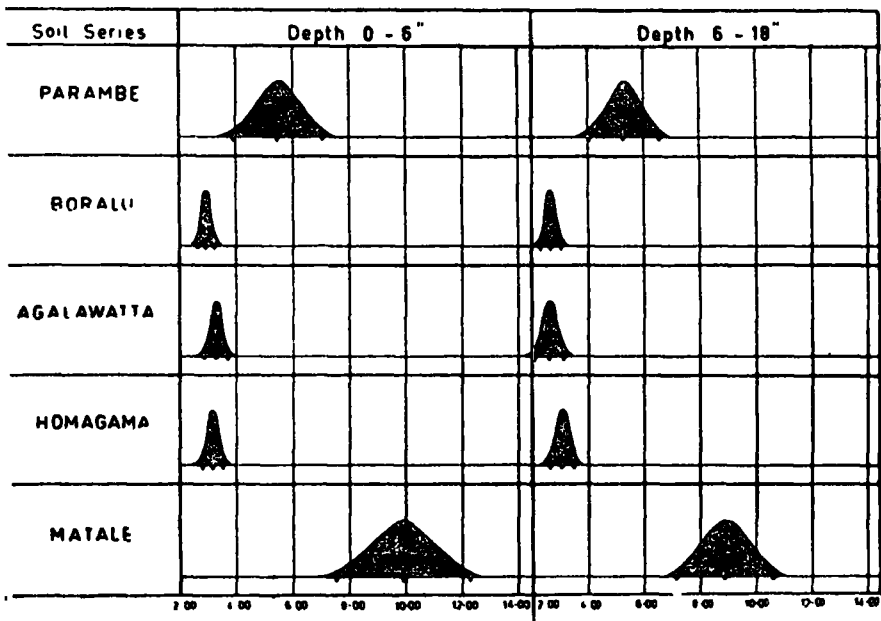


Fig. 7

## p H

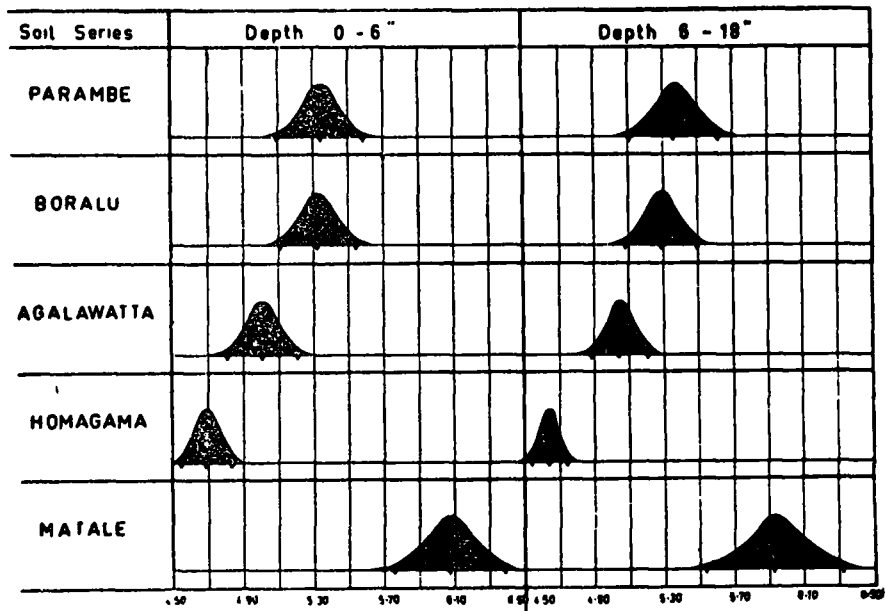


Fig. 8

Ranges for the cation exchange capacity and pH in soil samples  
from the different soil series

There is a considerable variation in the clay contents of these soils. The Parambe series has the highest clay contents having 30.95% and 32.96% at the two depths 0—6" and 6—18", respectively. The Agalawatta series has the next highest amounts of clay at the two depths being 26.62% and 27.44%. Next is Boralu which has 23.64% and 22.83% clay at the two depths followed by Homagama with clay contents of 20.16% and 22.56% at the two depths. The Matale series has the lowest clay contents but rather high fine sand fraction, *i.e.* 34.32% and 34.49%. The inverse relationship of clay content with coarse sand is also noticeable.

## (2) Leaf nutrient values

Table 3 gives the mean values of the different nutrients in the soil and in the leaves, taken from trees growing in the corresponding soil series. The mean leaf nutrient values have been collected from the data available of annual leaf analysis from the control plots of the departmental manurial trials. Such data for three to five years have been studied and are available only for the Parambe, Boralu and Agalawatta soil series.

The data shown in Table 3 indicate that except for the calcium and magnesium values in the leaf, the other three nutrients are lowest in the case of the Boralu series. Parambe has the highest content of leaf potassium and nitrogen while the leaf phosphorus levels are almost the same in all the series.

TABLE 3

NUTRIENT CONTENTS IN SOIL AND LEAF\* OF THREE SOIL SERIES

Soil series	N		P		K		Ca		Mg	
	Soil ppm	Leaf %	Soil ppm	Leaf %	Soil ppm	Leaf %	Soil ppm	Leaf %	Soil ppm	Leaf %
Parambe	0.092	3.29	144	0.211	1369	1.22	380	1.23	248	0.39
Boralu	0.071	3.08	77	0.202	207	0.59	97	1.09	36	0.32
Agalawatta	0.117	3.12	120	0.219	312	0.86	71	1.02	26	0.25

\* From the control plots of fertilizer experiments, for three to five years.

## Field experiments

The study of a few manurial trials indicates that in two experiments at the Kuruwita Sub-station there are responses to nitrogen, phosphorus and potash. The soil in this area is of the Boralu series and indicates that these soils require more fertilizers.

## DISCUSSION

John (1967) studied the levels of the different forms of potassium in the rubber soils and these values range from 7,983 to 752 of total potassium. The exchangeable potassium values in the same study range from 869 to 10. The values for reserve

potassium in the present study range from 1,369 to 207 for the 0—6" layer. Pavana-sasivam (1969) evaluated the amounts of the different forms of phosphorus, in the rubber soils of Ceylon, and arrived at a range of 638 to 90 of total phosphorus and 14.5 to 8.7 for available phosphorus. The values obtained in the present study are 308 to 77 and lie between the total and available phosphorus values as determined by the latter worker. This shows very clearly that by using HCl as the extractant, the values obtained reflect the reserve nutrient level of the soils studied.

The Matale series has the highest reserve phosphorus and also the highest exchangeable calcium and magnesium levels. The former character could be considered desirable but any excess of calcium and magnesium in the latex as a result of it being available freely would not be conducive for higher yields. The total nitrogen, organic carbon and the cation exchange capacity of this series is also the highest. Its reserve potassium level is also high but not as high as that of the Parambe series. The Parambe series has the highest amount of reserve potassium. The phosphorus levels as well as the exchangeable calcium and magnesium levels are also high. The cation exchange capacity of this series is high but its total nitrogen content is intermediate. Next comes the Homagama and Agalawatta soil series which have similar chemical properties. The reserve potassium and phosphorus levels as well as the total nitrogen and also the cation exchange capacity of these two soil series are intermediate in nature. The Boralu series soil exhibits a great paucity in mostly all nutrients and should be considered the poorest of all the soils studied. However a very important fact to remember is that in the Boralu series soil the exchangeable calcium and magnesium values are not very high, which signifies that if these levels are sufficient to supply the needs of the rubber trees; then the possibilities of pre-coagulation and consequent lower yields would not occur in the yield trends between the Boralu series and the other richer soil series.

The leaf and soil nutrient levels which are available only for the Parambe, Agalawatta and Boralu series, also show very clearly the poor quality of the Boralu series soil.

A field trial is undoubtedly the final test for the fertility of any soil. In the field experiments that are being conducted, there has been a regular positive response to nitrogen, phosphorus and potash, either singly or in combination, in two experiments being conducted at the Kuruwita Sub-station. This soil is of the Boralu series and indicates that the Boralu series is poor in nutrients.

#### CONCLUSIONS

The Parambe and Matale series contain the highest overall nutrient levels. The Agalawatta and Homagama series come next. The Boralu series is the poorest in nutrient content.

About half the area under rubber is planted in the Boralu series. At the present time it is economical to apply the higher levels of fertilizer to the comparatively poor Boralu series soils. As a result of this work it is suggested that instead of the R. 4 : 6 : 2 + Mg and R. 4 : 6 : 3 + Mg mixtures that are being recommended for the "lateritic" soils, the soils of the Boralu series should be given the R. 4 : 6 : 5 + Mg mixture. Changes in the nitrogen levels for the Parambe series soils and the phosphorus levels for the Agalawatta and Homagama series soil, could also be an outcome of this study.

On the basis of the data presented, it is rather a disturbing fact that almost 50% of the rubber lands are located in the poorer class of soil—the Boralu series soil. No systematic study has been made to evaluate the yields on this soil series and compare these yields with those of the other soil series which are not so poor in plant nutrients. A yield survey is essential before we can determine whether the nutrient status of the Boralu series soil is acting as a limiting factor to the economic production of rubber. The limited observations we have at present on the yield trends in this soil series, indicate that these yields are comparable to yields from other soil series and therefore the situation does not seem to be alarming. On the other hand if a survey reveals that the yields from the Boralu soil series are low, then further research investments towards a greater understanding of the mineralogical, physical and chemical properties of this series become very urgent, specially because of the large acreage covered by this soil series.

For the first time we know that the rubber soils of Ceylon have a wide variation in nutritional contents and the indications are that in some of the richer soils, like the Parambe soil series, we would be able to maintain the same level of production with less investments on fertilizer. With regard to the Boralu series soil, it is considered economically feasible to use fertilizer in this soil. But with the ever increasing fertilizer cost curve and a potential decrease in rubber prices, a better understanding of these soils would lead to higher yields and the continued cultivation of rubber at economic levels in the Boralu series soil.

It is considered very unlikely that the cultivation of rubber in the Boralu series would become uneconomic. But if these soils are not studied further and the yields from these areas are not increased, then it is possible that the benefits that could be derived from the continued cultivation of these soils would be marginal and not very economical. If this happens, and even if yields from the other areas were to be increased, as a result of newer and high-yielding clones, we could not expect substantial increases in production in the future. However elastic this product may be, it is very unlikely that a static level of production could meet the demand that is expected to increase in the future.

#### ACKNOWLEDGEMENTS

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#### QUESTIONS AND ANSWERS

Question : Do you think that there are any advantages in placing the fertilizer underground by using a foot 'alavango' when compared to broadcasting on the surface? (Anon).

Answer : Yes. There are many advantages, specially when urea is used as the source of nitrogen and in very hilly areas.

Question : When do you consider the most appropriate time to apply fertilizer to the mature areas? (Anon).

Answer : Two factors that decide on the best times of fertilizer application are the moisture status of the soil and the stage of refoliation. The soil should not be very dry or too wet at the time of fertilizer application. A time at which the fertilizer should be applied for maximum benefits would be when the leaves are falling from the trees at wintering so that the nutrients would be freely available at the time of refoliation. But unfortunately, wintering generally occurs during the dry season, so that the fertilizer could be added with the first few showers, after wintering.

Question : (1) How many lb of fertilizer per plant of 4 : 6 : 3 + magnesium do you recommend in the 1st year, 2nd year, 3rd year, 4th year and so on, on the Boralu soils?

(2) If we fertilize well during the immature stage, how much fertilizer do you require in the mature stage? (Anon).

Answer : (1) Our recommendations on the use of fertilizer in the Boralu series soil are found in our Advisory Circular No. 66. The mixture that should be used would be the R. 4 : 6 : 5 + Mg manure mixture.

(2) If during the immature phase any area had been fertilized according to our recommendations, then during the early mature phase 3 lb to 4 lb could be given per plant and 2 lb per plant later on up to about five years before uprooting, when fertilizer applications could be stopped.

Question : Is the application of excess nitrogen to young rubber plants harmful? (Mr. P. R. A. Fernando).

Answer : Too much of any nutrient would be harmful. Excess of nitrogen could result in a heavy canopy with resultant wind damage. This situation would be manifested mostly in mature areas. Excess of nitrogen would also cause nutrient imbalances and resultant deficiencies of nutrients other than nitrogen.

Question : (1) What do you consider the minimum maintenance dosage per tree in areas yielding :

(a) over 1,000 lb per acre

(b) under 1,000 lb per acre?

(2) Does the application of muriate of potash help the growth of "whippy plants" in new clearings?

(3) Does the application of urea as a foliar spray help the growth of late supplies in new clearings?

(4) For what conditions do you suggest the use of R. 4 : 6 : 8 —

(a) loss of leaf for *Phytophthora palmivora*,

(b) gravelly soils? (Anon).

Answer : (1) The amount of fertilizer that should be used for rubber does not vary with the yield as in the case of tea but differs with the age of the tree and is given in our Advisory Circular No. 66, on manuring.

(2) The trees referred to as "whippy plants" do not describe the situation sufficiently well. But if it is a condition of stunted growth with small leaves then it might be an instance of lack of mostly all nutrients. But if this situation is accompanied by symptoms of potassium deficiency then muriate of potash could be added, if it is felt that the addition of potash alone would correct this situation.

(3) Yes — to a certain extent when sprayed at the correct concentration.

(4) R. 4 : 6 : 8 + Mg is sometimes recommended when it is considered necessary to give additional potash and is not to be used as a routine fertilizer mixture.

Question : Boralu is a very poor soil indeed, but where the devil do you find it in Ceylon ? (Mr. Z. Boralugoda).

Answer : The approximate distribution of the different soil series in the South Western part of Ceylon are found in the RRIC Annual Review for 1968, and also in the RRIC Quarterly Journal Vol. 46, Parts 1 & 2.

Question : Re. Mr. Boralugoda's question, Mr. Silva referred Mr. Boralugoda to a map. Could he tell us what areas are covered by Boralu types ? (Mr. S. S. Perera).

Answer : The Boralu series soil is found mainly in flat or gently undulating terrain and occurs in a greater part of the western half of the Avissawella, Panadura, Horana, Alutgama and Ambalangoda 1 in. to a mile maps.

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