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Thesis Summaries

Extractable Minerals in Nine Malaysian Soils and Their Effect on the Mineral Contents of Four *Hevea* Clones

Three extractants, ethylenediaminetetraacetic acid + triethanolamine (EDTA-TEA), 0.025 *N* H_2SO_4 + 0.05 *N* HCl (DA), and 5 *N* HCl, were used to determine the extractable minerals in nine soil series under rubber [*Hevea brasiliensis* (Willd. ex A. Juss) Müll Arg.] cultivation in Peninsular Malaysia. Boron was determined by hot water extraction. Soil samples represented 0–15 cm and 15–30 cm depths in the tree-row and inter-row while profile samples represented four genetic horizons.

Relationship between mineral contents of soils and tissues of *Hevea* clone RRIM 600 growing on nine soil series was examined. Differences among clones as related to soil series were measured by collecting tissues from four different clones growing on two contrasting soil series. Tissues from these clones were collected in successive years to evaluate annual variations in mineral contents.

The reagent EDTA-TEA extracted the least amount of minerals from the soils except extractable P on Subang and Melaka, two soils very high in extractable Fe, exceeded that removed by DA. Extractable P, Cu, Zn, Mn, Fe, and Al were significantly higher by the 5 *N* HCl procedure. The DA reagent was generally equal to 5 *N* HCl in K and Mg extractions, and intermediate for other elements.

Fertility status of soils in this study was low, relative to most temperate soils. Mineral variations were attributed to clay minerals, quantity of clay and organic matter present, and cultural practices. Extractable micronutrients ranged from low to adequate, except Fe which was generally high. Micronutrient reserves were influenced by geochemical aspects of soil formation. Extractable Al ranged from 51 p.p.m. to 5350 p.p.m. as extracted by EDTA-TEA and 5 *N* HCl, respectively.

Distribution of mineral contents within soil profiles indicated poor reserves for many mineral elements. Leaching losses and (or) plant uptake resulted in low levels of K, Ca, and Mg. Extractable micronutrients changed very little with soil depth except for alluvial soils with lower horizons high in organic matter where 5 *N* HCl extractable Zn (12 p.p.m.) and Mn (11 p.p.m.) greatly exceeded levels found in other horizons.

Hevea grown on a number of soils contained below optimum levels of P, Mg, Cu Fe, and B in the leaves. Increased latex production was related to higher Mn concentrations in leaves and soils; however, there was no conclusive trend to infer that a specific nutrient (or nutrients) was involved directly in limiting latex yield. It is possible that interactions between nutrients and nutrient ratios exert considerable influence on latex production.

Significant differences in leaf mineral contents found among the four *Hevea* clones could not be clearly attributed to clonal or soil effects because of wide variations in extractable minerals within a soil series. Variations in mineral contents of bark and bark-scrap rubber sampled in successive years were not good indicators of fertiliser responses.

Correlations of minerals in *Hevea* tissues and soil extractable minerals by the three

extractants for soil samples taken from several sites were inconsistent or non-existent except for Mg and Mn where *r* values as high as 0.396 and 0.731, respectively, were found. Differences in soil series combined with types and methods of fertiliser application seem to prevent good overall correlations.

Relatively high concentrations of micronutrients, especially Cu (1 – 9 p.p.m.), Zn (26 – 66 p.p.m.), and Mn (78 – 287 p.p.m.), were found in the bark-scrap rubber. Long-term effects of continuous crop removal, plus an increase in latex production stimulated by macronutrient fertilisation, could result in an appreciable depletion of these elements since reserves of these elements appeared to be quite limited.

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Contributions to Improve the Effectiveness of Breeding, Selection and Planting Recommendations of *Hevea brasiliensis* Muell. Arg.

A detailed study of the RRIM breeding programme has revealed deficiencies in the post-war phases. These deficiencies have delayed breeding progress. Changes in procedures have been proposed for breeding programmes to be more efficient and economical.

It is difficult to produce good all-round clones quickly using only the conventional method. Results of study of three other approaches show that:

- Mother-tree selection in polycross populations obtained from seedgardens gave high yielding clones in the nursery.
- Wide crosses of interrelated eastern clones and SALB resistant materials showed apparent heterotic effects. Interpopulation crosses therefore have potential to speed up rubber improvement.
- Crown budding can extend the range of usable clones and reduce the dependence on breeding for high yield and good secondary characters simultaneously into one clone.

These fresh approaches and the conventional one depend on a wide genetic base for more rapid progress. This is only feasible if there is a permanent commitment to the conservation of genetic variability in the form of a major collection.

The rubber industry can only take full advantage of the high yields observed in experimental plots if these yields can be quickly realised in commercial plantings. Shortcomings in the general planting recommendations, however, often reduce the yield productivity potential of the clones and also delay the use of these clones on a wide scale.

Formulation of the Enviromax Planting Recommendations allows realisation of the full potential of a particular environ by avoiding predictable interactions. This approach also allows new clones to be upgraded and exploited more quickly by the rubber industry.

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Potassium and Magnesium Adsorption and Release Characteristics of Some Malaysian Soils

Potassium, magnesium and aluminium in five contrasting soils of Peninsular Malaysia were extracted by H^+-saturated cation-

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exchange resin. Preliminary investigations showed that K, Mg and Al were rapidly taken up by the resin during the initial seven days and after this period, the cations were released to the resin very slowly.

The difference between K, Mg or Al extracted by H^+-resin and exchangeable values determined by 1*N* NH_4OAc was considered to be the non-exchangeable fraction. These non-exchangeable fractions of K or Mg in the soils were low to moderate. The low nutrient status thus reflects the advanced stage of leaching and development of the soil. Unlike non-exchangeable K and Mg fractions, the non-exchangeable Al fraction was very high, suggesting ready solubilisation of Al compounds in the soil complex.

The rates of release of K, Mg and Al from the soils saturated with K and Mg at varying equivalent K/Al and Mg/Al ratios were found to follow the pseudo-first order kinetics. The rate constants for the release of the cations appear to reflect the chemical characteristics of the soils which are influenced by particle sizes, organic matter contents and type of minerals present, but do not provide any clue as to the mechanisms which control the release of the cations. In contrast, the rates of adsorption of K, Mg and Al from 0.1*N* solutions containing either K and Al or Mg and Al at varying equivalent K/Al or Mg/Al ratios were different for all the soils and found to follow a 'parabolic' rate law for up to 75% – 85% K- or Mg-saturation. It appears that in the present investigation, the adsorption process was determined by the diffusion of K, Mg or Al ions into the sub-surface layers of the soil particles.

K:Al and Mg:Al equilibrium measurements on the soils showed that preference for K^+ to Al^{3+} or Mg^{2+} to Al^{3+} varied with the concentrations of K or Mg in the equilibrating solutions and saturation of the soil by K^+ or Mg^{2+} ions. Selectivity coefficients indicated greater preferential adsorption of K^+ to Al^{3+} at low K-saturation of the soil, while Al^{3+} was preferred to Mg^{2+} over the range of Mg-saturation studied. Standard free energies of exchange showed that formation of K-soil was preferred to Al-soil in two soils, while formation of Al-soil to Mg-soil was preferred in all the five soils.

Apparent specific surface areas of clay fractions were determined by the cetyl pyridinium bromide (CPB) adsorption method. In clays containing very little or no expanding 2:1 minerals, specific surface areas by the CPB adsorption method were in agreement with the values determined from the maximum adsorption of methylene blue to produce optimum flocculation. In all the soils, the first-order rate constants for the release of Mg or Al to H^+-resin and the 'parabolic' rate constants for the adsorption of Mg^{2+} or Al^{3+} ions were linearly correlated with the apparent specific surface areas of the soils.

The effects of K and Al treatments of the soils on growth and nutrient uptake of rubber seedlings were also investigated. Significant reduction in dry matter yield was observed when the rate of Al applied was increased. Interaction between K and Al on dry matter yield was not significant. At higher levels of Al application, uptake of P, K, Mg, Ca and Mn as determined by total nutrient contents in the seedlings were inhibited. The antagonistic effect of K on uptake of Mg, Ca and Al was also evident. The concentrations of K and Al in the equilibrium soil solution were also determined and attempts were made to relate plant uptake of K and Al to K and Al in the equilibrium soil solution.

The study confirms that the non-exchangeable reserves of K and Mg in the soils are low. The soils are also not able to retain added K or Mg. This emphasises the need for a well planned fertiliser programme for optimising productivity of a crop. Further, the dominance of Al^{3+} in the soils clearly indicates the need for its inclusion in assessment for K and Mg in these soils.

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